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ABSTRACT

This compilation of conference materials consists of: programme, inaugural and closing addresses, working group reports, background papers, and a reference document. The principle substantitive items are the working group results and the background papers. Within the overall conference theme of "Education and New Information Technologies," the following topics are covered. Working group reports: (1) policies, strategies, and tools of implementation; (2) impact on learning; (3) changes in curricula; (4) new teaching functions and related training; and (5) software and courseware for a multimedia educational environment. Background papers: (1) policy trends and developments in member countries related to the introduction of new information technologies in elementary and secondary education; (2) trends and issues in higher education; (3) research and development relating to educational applications; (4) software and courseware for a multimedia environment; (5) economic aspects; (6) information society and general education; (7) new teaching functions and implications for new training programs; (8) curricula and institutional structural changes; and (9) impact on learning processes in formal education. A final reference document deals with overall trends and issues and attempts to synthesize the background papers. (MBR)

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INTERNATIONAL CONFERENCE ON EDUCATION AND NEW INFORMATION TECHNOLOGIES

9th-12th July 1984

PROGRAMME

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MONDAY, 9th JULY

Afternoon	Plenary Session: Room 1
2.30 pm - 3.00 pm	Conference Inauguration and Opening Remarks by the Secretariat
THEME 1:	**GENERAL POLICIES IN THE INTRODUCTION OF NEW INFORMATION TECHNOLOGIES IN EDUCATION** President: The Honourable Bette STEPHENSON, Minister of Education, Minister of Colleges and Universities, Ontario, Canada
3.00 pm - 3.30 pm	Inaugural Address by the President: "Information Technology, Society and Education"
3.30 pm - 4.00 pm	Policy Trends and Developments in Member Countries, by Mr. J. Ronald GASS, Director of CERI, Director of Manpower, Social Affairs and Education (ref. CERI/NT/84.02 and CERI/NT/84.03)
4.00 pm - 4.20 pm	Break
4.30 pm - 5.30 pm	**Teleconference with:** -- Mr. Alain SAVARY, Minister of National Education, France, at OECD Paris -- Dr. Terrel BELL, Secretary of Education, United States, in Washington, D.C. -- The Hon. David KING, Vice-Chairman of Council of Ministers of Education, Minister of Education, Alberta, Canada, in Edmonton -- Mr. Kenneth BAKER, Minister of State for Industry and Information Technology, United Kingdom, in London
5.30 pm - 6.30 pm	General discussion
6.30 pm - 8.00 pm	Reception offered by the President, the Honourable Bette STEPHENSON, for all participants, Château de la Muette

TUESDAY, 10th JULY

Morning	Plenary Session: Room 1
THEME 2:	**EDUCATION AND NEW INFORMATION TECHNOLOGIES: MAIN ISSUES** President: The Honourable Bette STEPHENSON, Canada
9.00 am - 9.30 am	Overall trends and main issues, by the Secretariat (ref. CERI/NT/84.11)
9.30 am - 10.30 am	Economic Aspects of the Introduction of New Information Technologies in Education, by Jean-Claude EICHER (ref. CERI/NT/84.06) and general discussion
10.30 am - 11.00 am	Break
11.00 am - 12.00 am	Software and Courseware for a Multimedia Educational Environment, by Yves LE CORRE (ref. CERI/NT/84.05) and general discussion
12.00 am - 1.30 pm	Demonstration of hardware and software for Working Group 1
1.30 pm - 3.00 pm	Demonstration of hardware and software for Working Group 2

Afternoon

3.00 pm - 6.00 pm Working Groups

TOPIC 1: EDUCATION AND NEW INFORMATION TECHNOLOGIES: POLICIES, STRATEGIES AND TOOLS OF IMPLEMENTATION
(ref. CERI/NT/84.02, 03, 06 and 11)

Working Group 1: Room 1

President: Arthur MELMED, United States — Rapporteur: Tjeerd PLOMP, Netherlands

TOPIC 2: THE IMPACT OF NEW INFORMATION TECHNOLOGIES ON THE EDUCATIONAL SYSTEM
(ref. CERI/NT/84.08, 09 and 10)

Working Group 2: Room 4

Main focus: The impact on learning

President: Don FITZGERALD, Australia — Rapporteur: Jacques NAYMARK, France

Working Group 3: Room 9

Main focus: Changes in curricula

President: Roy ADAMS, New Zealand — Rapporteur: Mario FIERLI, Italy

5.00 pm - 6.30 pm Demonstration of hardware and software for Working Group 3

Working Group 4: Room 6

Main focus: New teaching functions and related training

President: Martyn ROEBUCK, United Kingdom — Rapporteur: Denis HEALY, Ireland

TOPIC 3: SOFTWARE AND COURSEWARE FOR A MULTIMEDIA EDUCATIONAL ENVIRONMENT
(ref. CERI/NT/84.05)

Working Group 5: Room 3

President: William BRODERICK, United Kingdom — Rapporteur: Raymond MOREL, Switzerland

WEDNESDAY, 11th JULY

Morning — Working Groups

9.30 am - 12.30 am Continuation of the Working Groups

11.30 am - 1.00 pm Demonstration of hardware and software for Working Group 4

1.00 pm - 2.30 pm Demonstration of hardware and software for Working Group 5

Afternoon — Working Groups

2.30 pm - 4.30 pm Preparation of conclusions and recommendations concerning future work.

4.30 pm - 6.30 pm Demonstration of software and courseware

THURSDAY, 12th JULY

Morning	Plenary Session: Room 1
THEME 3:	INFORMATION SOCIETY AND GENERAL EDUCATION
	President: Professor Claude PAIR, Directeur des Lycées, Ministry of National Education, France
9.30 am - 10.45 am	Panel discussion: Moderator: George S. PAPADOPOULOS, Deputy Director for Education, OECD -- Daniel GRAS, France -- Giovanni LARICCIA, Italy -- Jacquetta MEGARRY, United Kingdom -- Joseph WEIZENBAUM, United States (Ref. CERI/NT/84.07)
10.45 am - 11.15 am	Break
11.15 am - 12.30 am	General discussion
Afternoon	Plenary Session
THEME 4:	GENERAL CONCLUSIONS AND FUTURE WORK
	President: Mr. John R. STEINLE, Director General of Education, South Australia, Australia
2.30 pm - 3.00 pm	Conclusions and recommendations of the five Working Groups, by the Group Rapporteurs
3.00 pm - 3.15 pm	Needs in Research and Development, by the Secretariat (ref. CERI/NT/84.04)
3.15 pm - 4.30 pm	General discussion on future work
4.30 pm - 5.00 pm	Synthesis and conclusions by the General Rapporteur, Professor Gilbert DE LANDSHEERE, Director, Laboratory of Experimental Pedagogy, Université of Liège, Belgium
	Closing Remarks by the President

ORGANISATION FOR ECONOMIC
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INAUGURAL AND CLOSING ADDRESSES and WORKING GROUP REPORTS

(Note by the Secretariat)

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Inaugural speech by the President
The Honourable Bette Stephenson,
Minister of Education, Minister of Colleges and Universities,
Ontario, Canada

Ladies and Gentlemen, I have been asked, as your Chairman, to make an opening statement, which will in a general way set out some of the issues we shall address in this conference, issues which in our various ways we must each address in our own jurisdictions.

None of us would be attending this conference if we did not believe that our economies and societies are in a process of transformation catalyzed by the ever more extensive and intensive use of the new micro-electronic technologies. Any such general transformation must, of course, create new demands and new challenges for education and training and it is about some of these that I would like to speak for a few minutes.

You will note that I take it as given that our economies are being transformed by the application of micro-electronics. Whether this is happening positively and directly as a result of the active application of the new technologies, or negatively and indirectly as a result of failure to apply them, the impact is and will be profound.

Without necessarily embracing the popular rhetoric of an Alvin Toffler, it seems undeniable that as we change the basic processes and functions on which our economies depend, we must inevitably change the nature of our social structure and probably many of its important underpinnings. If for no other reason, education, as a major instrument for helping young people to understand, to adapt and to sustain the world in which they find themselves, must also change.

Because the children now entering school will graduate from university in the twenty-first century, we must take a long-term view of the changes which are occurring to prepare our children for the kind of world they are likely to encounter. This I presume is in large measure the rationale for the conference we are now beginning.

It was on this continent long before the corner of the world in which I live was settled by our forefathers that the printing press became the key technology to learning. Today the key technology is the microchip for the "information society". The form in which we can see its potential most clearly is in the computer, the most symbolic product of the technology of the microchip and electronic micro-miniaturization. We are being propelled increasingly quickly into the "Third Wave" because modern technology has produced computers, or variations of them, small enough and cheap enough to be part of almost every device we use, converting them into semi-intelligent devices with the ability to store and be guided by the information needed to operate them.

It is very clear today, and even clearer in the years ahead, that each individual must necessarily understand something about the computer in order to comprehend more and more about our world. This understanding, often called "computer literacy" is something that schools must obviously begin to provide. As in most things, one understands best by doing, therefore, schools must not only teach about computers, they must teach with computers and allow the student to use them as personal learning tools, like textbooks, notebooks and libraries. Just as the immense communications and information processing abilities of computers transform most processes of which it becomes a part, so does the computer transform the nature of education and the functions of teachers and schools.

The structure and use of computers, and their effects, must become subject of instruction almost universally to draw an analogy between traditional "literacy" and "computer literacy" is not misplaced. If "literacy" is the medium for communication amongst ourselves, "computer literacy" is rapidly becoming the medium for communication between ourselves and the devices capable of doing the work of the world which we must learn to direct and control in our daily lives. At the very least, all of us will require some basic understanding about computers and what they do and -- for simple devices based on computers -- how to use them. Beyond this, our schools must make widely accessible to everyone with interest and ability, a more extensive understanding of the nature of computers, how they operate and how to use the more sophisticated.

Computers, however, must not only be learned about, they must become widely used in the process of instruction in most other subjects. A second objective is, therefore, to ensure that we take full advantage of the computer to improve instruction generally. It seems very likely that general "computer literacy" which is increasingly needed will not be best achieved, for most students, by specific courses about computers but rather by ensuring that students of all ages use computers, in a natural way, as personal learning tools.

The vast information storage capacity of the modern microcomputer makes possible (on a large scale) a generally unattained goal of educational reform for the past fifty years.

The computer can evaluate the student's prior knowledge, leaping ahead or dropping back in the instructional sequence as required. Instructional sequences can be branched, following different pathways depending on the student's progress and report that progress to the teacher. At the same time, it is capable of identifying the points in the instructional sequences which cause the greatest difficulty. The pedagogical effectiveness of such programmes will be limited not by the machines but by the insight and imagination of our educators.

In a further extension of this ability, computers can be programmed with data which allow the simulation of real life situations. We are familiar with this concept in some of the more sophisticated video arcade games, such as guiding a space ship to a safe landing through the mountain ranges of the moon, or a car along a busy highway. There are almost unlimited pedagogical applications for this kind of simulation, from teaching safe driving, to first-aid and human physiology, to advanced physics, where the real situation is too dangerous or too expensive to allow the student to "learn while doing".

The modern computer has also made possible the creation of the huge comprehensive data banks which now exist in almost every field of knowledge. The computer, when combined with modern communications technologies, permits the smallest and most remote schools and the most isolated student information resources with an ease and on a scale never before possible.

In all the examples I have noted, the student is provided a learning opportunity through reaction to a programme, simple or complex, designed by someone else. We know that learning which is self-motivated, which follows the promptings of one's own curiosity is ultimately the most engaging and stimulating and long lasting.

The computer supports this kind of free, creative personal discovery and learning as well. It may be in this mode that the computer can make its greatest contribution to learning, acting as a personal learning tool, revealing implications and inter-relationships which might come only years later in the normal course of learning and development. The computer, used this way especially, may be able to accelerate the normal rate of cognitive development and, at each stage of development, to broaden and expand the range of ideas which can be assimilated.

At the other end of the spectrum, computer programmes can provide drill and practice in essential skills and knowledge, often as a type of interactive game heightening interest in what is otherwise an important but tedious task.

Our instructional objectives must, therefore, be to provide the knowledge about the new information technology that will be needed in a world in which these technologies are the principal tools and to make the best possible use of them in improving learning. Clearly, each objective must and should support the other.

Most of the people in my generation, and I suspect most of you here this afternoon, have grown up in a world rooted solidly in the values and practices of an industrial economy. In our world, the computer has been a new device which could be left to a small group of professionals. For many of my generation, it is often difficult to comprehend why we must consider seriously the changes the new information technology is propagating. How often have you heard, for example, the opinion of some in the schools that the computer is just another fad -- like the opaque projector, the teaching machine, movie projects and educational TV -- that will come and go without much impact on traditional methods of teaching and learning.

If anyone of us believes that, we stand guilty of perpetrating a damaging disservice upon our students. If the schools believe that, the world of the school will find itself cut off from the larger world around it. Without regular use of computers, our students will be unable to develop the innate ease with and understanding of the device that is fast becoming the medium through which most of the world's work will be conducted. Equally important, they will suffer the loss of the dramatic improvement in learning which the appropriate use of computers in education can help provide.

It is this improvement in the productivity of learning that in my view has the greatest significance for the future role of the school. Let me hasten to note that increased productivity does not signal the replacement of teachers by machines. In our schools, we need all of the teachers, all of the human contact we can afford. Although we have tried very hard to improve the efficiency of learning we seem of late to have reached an outer limit with the resources and methods now available to us. In most educational systems, we accept the fact that the majority of our students -- in practice -- master only a fraction of the intended curriculum. And it is not because the teachers are poor or that they don't work hard and intelligently.

The new technology gives us an opportunity to move beyond this impasse, if we use it positively and creatively. Although we are still at the early infancy stage of development in educational computing, the best state-of-the-art lessonware and courseware can do superbly many of the routine tasks which too often occupy so much of the teacher's time and energy that very little is left for the stimulating, more creative and more professional aspects of teaching. In effect, we can automate many of those routine functions and automate them in ways which students find engaging, in ways which can be individualised, in ways that a teacher in charge of a class of twenty-five cannot possibly do, and with a patience that even a saint could not equal! I may be overly optimistic but at least potentially we are much closer to being able to achieve something like true mastery learning, in almost 100 per cent of the intended curriculum.

And as we become more proficient in the design of educational software, we can develop even more sophisticated learning aids, and as more powerful and versatile computers become more widely available, our students will become more proficient in the creative personal use of the computer. Through all of this they will be extending their conceptual grasp and accelerating their intellectual development.

Obviously, such development has immense implications for the role of the teacher, for the role of the school and, indeed, of formal education. If we decide it is a direction in which we would like to move, and if we make the necessary investment, it is perfectly feasible to imagine classrooms, ten or fifteen years from now, in which most of the basic intellectual content and processes of the curriculum are learned with the assistance of the computer. Not, I might add, by students isolated from one another, rather in small groups or teams in direct contact or linked through shared intercommunicating terminals, working collectively on challenging problems. These students will not necessarily be working in the school. Within the school, much of the work of the teacher will be with individual students in coaching, in diagnosis of problems, in helping to find the right materials, and in developing new materials as needs are identified.

But much as well will be with groups, who have pushed beyond the acquisition of cognitive basics of the curriculum. The teacher, able to assume that knowledge base, will help students to establish the deeper understanding which grows from discussion of ideas and concepts and from pondering their significance. Students and teachers will develop the personal interaction, through skillfully led group discussion, upon which true comprehension depends and which leads to examination and understanding of the social and moral dimensions of the knowledge gained.

This kind of higher cognitive and affective learning must become the strength of the school of the future, adding the vital human dimension to learning which no machine can replace or mediate.

It will be difficult to make this change because teachers will have to relate the familiar, comfortable routines to computer networks and data bases, and take on the difficult, creative and emotionally demanding role of humanist guide to a group of students whose intellectual development continually outstrips their human understanding.

Surely the school is the natural setting for this kind of personal growth and the skilled professional teacher its natural mentor.

But, if I may be somewhat pessimistic, if the school cannot assure this role, if it cannot become more skillful and effective in this activity than other agencies of society, there may be little future for school as we know it. If the school serves only as a warehouse for computer terminals, or if it refuses to make use of the technology, it will be bypassed as irrelevant. The computer can operate equally well in the home, in the public library, the office or factory. There must be a reason to go to school and school must accept that fact and meet the challenge, if it is to survive.

This raises a second major point which, I believe, we must explore thoroughly in our discussions this week, the structural alterations the new information technology will bring about.

As educators, we should be principally concerned about the educational potential of the computer; the productivity improvements we can benefit from if the new technology is effectively used and, of course, about the new learning demands which the pervasive use of a new dominant technology places on formal education.

But as policy makers, we must be equally concerned about the structural side effects of the increasing use of the new technology.

The proper use of the computer can greatly increase the productivity of our educational system in the sense of achieving greater learning with an equal investment of resources. This is obviously just one specific instance of an important generalisation which can be made about the new technology. In whatever field, if effectively used, the new technology results in productivity increases. Indeed one can further generalise to say that no country's economy, or no sector of that economy, will remain competitive unless it takes full advantage of the improvement in productivity which the new technology makes possible.

But fully automated industries are clearly less labour intensive than are conventional industries. In addition it seems unlikely that the traditional sectors of the economies of OECD countries will grow in general, at a rate which will compensate for the attendant displacement.

Structural unemployment is, therefore, a reality. Surely we are much more likely to deal with it effectively if we approach it through thoughtful re-structuring of our work and social patterns and through search for renewed economic growth in new sectors of the economy, than we are if we insist upon repeating the tired formulae of the past.

These circumstances force another set of challenges for the education and training systems.

As the rate of change and the rate of displacement remain high, the need for re-training, on a permanent life-long basis will be evident as it has never been before. That training must be highly flexible, quickly mounted and rapidly responsive to changing needs dictated by changing technologies.

As most of us are aware, the traditional formal educational and training systems are not particularly noted. But they must *acquire those talents or suffer total replacement by* newer, more rapidly adaptive systems.

One could indeed suggest that the new technologies themselves provide the best means of coping with new trainng needs; flexibly deployed in home, office, factory and shop; rapidly developed as new needs become apparent; highly adapted to individual learner needs and significantly self-paced.

Perhaps, in this area, the institutions will not be the prime deliverers of training (and by trainng, I mean any form of instruction designed to lead to mastery of specific knowledge or skills) but will be rather, the repositories of expertise in instructional design, the developers of new educational software, expert consultants on the training process to both the individual seeking training or re-training, and the enterprises with new training needs.

One can imagine some of our established institutions evolving into such a role; indeed some already have; one can imagine others declining quietly into increased irrelevance and ultimately succumbing to total atrophy.

While one can visualise the evolution of certain institutions into a species of central "service" bureau for a widely dispersed, flexible and informal training system I would not wish to imply that all of formal education can or should be reduced to a body of specific knowledge and skills whose acquisition the computer can facilitate.

To the extent that true education goes far beyond such definition, to the extent that our educators are able to utilise the new technologies for the excellent pursuit of valuable purposes and are willing in their own efforts to extend well past the mere mechanics of their calling, therein lies the deep and largely unexplored area which is the important future for formal education.

We have glimpsed this future in our understanding of the way in which the role of the teacher and the role of the school should change in light of the advent of an effective electronic technology of training.

There are vital attitudinal changes we must strive to achieve within and throughout our educational systems which require insightful planning from the earliest to the most advanced levels.

We must first, both in a cognitive and a psychological sense, identify a range of what might be called "coping skills".

These begin with the cognitive basics on which future learning depends. We cannot know the future other than to know that we shall need constantly to learn and re-learn. Young people to the greatest extent possible must, therefore, derive confidence and inner security not from their mastery of a given body of knowledge and/or specific skills, but from their mastery of the techniques of learning and the knowledge that they can learn what is required when it is required.

I would include amongst the basic coping skills, some ability to tolerate ambiguity, some psychological ability to deal with uncertainty, for change will probably be our only consta[illegible]

And, wherever it is possible to develop it, I would include originality and creativity, the ability to see old things in new ways, all coupled with the skills and attitudes of entrepreneurship. These I think, are vital because only out of creative entrepreneurship will we generate continued economic growth in a world dominated by the new information technologies.

This suggests that the arts and much of the general cultural content of education, far from being displaced, take on new importance as the means of helping people to acquire the strength and skills to cope with a world in which the determining factor for personal satisfaction and success will more than ever be the range and depth of one's own inner resources.

Ladies and gentlemen, perhaps I am being overly poetic, or "spirituel" for OECD purposes. I hope, nevertheless, that I have stirred thoughts about the nature of the challenge we face. However we may formulate the problems, the need for a sensitive, logical and rational approach to public policy is obvious. I look forward to this conference as a source of inspiration and assistance. The nature of our task, the balance we must maintain and the harmony we have to achieve comprise an enormous undertaking. It is an undertaking that I am sure in our different ways we can -- with goodwill, trust and optimism -- address effectively if we work in co-operation with one another.

Report from Working Group 1

POLICIES, STRATEGIES AND TOOLS OF IMPLEMENTATION

President: Arthur Melmed, United States
Rapporteur: Tjeerd Plomp, The Netherlands

Summary and Conclusions

Despite the potential -- identified in analyses carried out within the CERI project -- of NIT to change education radically in its very structure and organisation of production and delivery mechanisms, no government delegations represented in Working Group No. 1 acknowledged the consideration of such a far reaching policy. Instead, policies of Member nations appear to be concerned with the implementation of computers -- the centerpiece of NIT -- in the school curriculum at different budgetary levels and levels of sophistication, without concern for the minimum level of implementation required to make a significant improvement in student learning. Level of sophistication varies among teaching about computers, various forms of computer-assisted instruction and computers as personal tools for students.

As the level of experience and the availability of intellectual and scientific resources required for the effective execution of this policy of incremental change in schools differed sharply among nations, there were clear expressions of interest by nations with relatively slight experience to benefit from the experience of the others, and for OECD to facilitate this process. Experience-rich nations indicated an interest and willingness to co-operate. Areas for study and assistance proposed by the delegates for consideration are identified below.

Recommendations

a) From countries with considerable experience and a rich programme of computer activities, it is possible -- with their assistance -- to gather data on what works; on costs, effectiveness and benefits; and on any unanticipated adverse effects. This information would be of great benefit to countries with only slight experience.

- -- It is recommended that the OECD considers ways and means for facilitating the efficient transfer of this information and knowledge among Member nations.
- -- In considering this activity, it is recommended that the OECD gives special attention to instrumental uses of computers that may reveal levels of implementation that have an educationally significant effect on student learning.

b) Change influenced by the level of computer implementation that may be required for educationally significant effects on student learning is likely to be resisted by the accompanying shift of power among stakeholders in the schoolworld.

-- It is recommended that the OECD studies this phenomenon with a view to identifying effective strategies for mediating school change.

c) Educational decision-makers who lack knowledge of the potential and experience in the planning of computer applications of all kinds in education, are a barrier to advancing the use of this option, or can often be oversold on this option by representatives of the commercial sector who also gain from these activities.

-- It is recommended that the OECD considers establishing a training programme for senior educational decision-makers to correct this problem.

d) Educational software is viewed by delegations as the critical factor affecting the successful implementation of computer use by students.

Information on existing educational software is often unavailable outside the country of its origin, and often not conveniently available in a useful form even within its country of origin.

It is recommended that the OECD should consider ways of disseminating information on existing software, and perhaps on its effectiveness. Many authoring systems exist to facilitate the efficient production of courseware. Their effectiveness for the purpose of building up an inventory of critical size is diminished by the absence of standards or guidelines that would facilitate exchange of courseware products in some form. This point is taken up in greater detail by Working Group No. 5.

e) The nature and content of programs of computer literacy are debated largely because countries differ on the underlying assumptions and the role which the educational system should play in it. It is certain that the nature and content of these programs will undergo change in the future as the people at large become more familiar with NIT and as computers become more user-friendly.

-- It is recommended that the OECD monitors this potential change and periodically informs educational decision-makers of new trends among Member countries.

f) Educational systems ought to be reflecting the needs of the society. This is more than satisfying the need for skilled manpower, but encompasses also general educational goals like transfer of culture and preparation of the young for their position in society. Our present educational systems are set up to serve the needs of an industrial society. School curricula are always in the process of negotiation, which -- as long as the paradigm of our society is not fundamentally changed -- is initiated by and is mainly contained within the educational system itself.

It is argued by many people that the "paradigm" of our society is in the process of changing. NIT are permeating all sectors of society (work, homes...) in such a way that our work and living environment is changing fundamentally. Characteristic of this is that people will work with information machines, i.e. that there is a shift from humans to machines with respect to manual and cognitive skills. Certain skills and knowledge are no longer of value as before, new ones are valued highly.

According to many, we have to reconsider our cultural values and, in the light of this, the objectives of our educational system. The deep relationship between NIT and education calls therefore for a review of the cultural patterns and the educational models that underly the syllabuses of different disciplines. To face the challenge of an "information society", the relationship between knowledge learned and know-how to be learned needs to be reconsidered. This is not a concern for any single country but a mondial one, which can benefit greatly from international co-operation.

-- The OECD is recommended to consider taking the lead in this activity by setting up a study process in which countries may contribute via national working groups, reflecting the various national and cultural contexts which are of relevance.

g) Development and research on advanced paradigms needed to improve the effectiveness of computerised interactive instruction -- such as expert systems -- might be facilitated by some form of international co-operation.

-- It is recommended that the OECD examines ways of facilitating communication among experts and researchers of Member countries on this subject.

Report from Working Group 2

THE IMPACT ON LEARNING

President: Don Fitzgerald, Australia
Rapporteur: Jacques Naymark, France

The first part of this report attempts to reflect the liveliness of the Working Group's discussions, in particular the keen debate on the whole question of the NITs as an educational medium, a teaching tool and/or a social issue of a new culture. These discussions were probably coloured too by views on educational values and policies.

The second part outlines some key areas: development, reflection, and recommendations for research, application and training. Here too there is some circumspection concerning the value of NITs as a means of resolving, as if by magic, difficulties in inculcating, say, the rudiments of language and mathematics in every pupil. However, it is agreed that the use of NIT offers an unprecendented opportunity to improve the effectiveness of these basic learning processes, which pose a problem in all countries.

The third part presents recommendations as regards international co-operation and the role that CERI might play.

a) The difficulty of categorising the roles and impacts of NIT on learning processes, quite apart from the varying connotations of such terms as "information science" and "computer science" presented a very real problem to the group. While there was agreement that the learning of computer programming should be in the secondary cycle and in pre-vocational streams, there are still doubts about the pedagogical value of earlier initiation in computer logic as an alternative mode of logical reasoning. The cognitive sciences are therefore being challenged as to whether and how such "reasoning" can be applied in other areas.

As a tool, for the purposes either of teaching or of data processing, the computer in its instrumental aspect is perceived differently depending on whether the focus is on its effectiveness, the irreversibility of its use in the productive system or the risks of widening social inequalities and the illusions it may nurture.

b) Lines of development and recommendations for research:

-- Information science as the instrument of an epistemology of knowledge:

  i) Acquisition of mathematical reasoning (formulation of hypotheses), scientific concepts (weight/density, temperature/heat etc.);

  ii) Cognitive processes, transfers and learning processes;

iii) Representation of concepts and communication of knowledge.

-- Computer science and organisation of learning processes:

  i) Stratification by learning age (primary, secondary, mainstream/vocational education);

  ii) Organisation and management of time and place of school learning (frequency/timetable, computer access and utilisation rate);

  iii) The paradigm: individualisation of the learning processes and the socialising function of school.

-- The computer and pedagogical evaluation:

  i) Of the knowledge acquired by learners;

  ii) Of differences between individuals and groups;

  iii) Of the efficiency of the methods chosen by teachers;

  iv) Of scholastic results and performance.

-- Specific application of NITs:

Learning to use NITs as a data processing tool as such:

  i) Use of word processors (are they helpful in learning to read and write?);

  ii) Consultation of data banks: learning how to search for, process and store information;

  iii) Applications in the productive system (electronic currency, robotics, office automation etc.);

  iv) Ergonomics of software and courseware should be developed to facilitate their use.

c) Recommendations for co-operation:

-- CERI could set up a data bank on ongoing research and on existing courseware. Creation of an electronic network could be the subjet of international co-operation;

-- CERI could publish research findings, including those of this conference, and facilitate translation and dissemination of the studies.

Report from Working Group 3

CHANGES IN CURRICULA

President: Roy Adams, New Zealand
Rapporteur: Mario Fierli, Italy

INTRODUCTION

The diffusion of new information technologies is expected to change the nature of working processes, everyday life and society in general.

Changes in society necessarily induce changes in the school systems. The time and the velocity of this change can vary for different countries as well as for different sectors or levels of the educational system. They depend not only on the kind of involvement of a particular country in the use or production of NIT, but also on their resources and their capacity to modify curricula.

CONCLUSIONS

a) Partnership

The school system can receive substantial help, in its development, from different partners: industry, social organisations, trade unions and universities. There remain necessarily, important issues over the control of curricula and the quality of the educational process.

b) A Perspective

A rapid diffusion of research results between different countries can be helpful in reducing the risk of lag in policy formulations, experimentation, evaluation and production.

c) Conditions for Change

The production of quality software and hardware and the effective training of teachers in the use of NIT are all essential for progress. However, if reform is to be effective, they must be accompanied by effective implementation strategies that give due attention to organisation infrastructures and frame factors affecting the everyday operations of schools.

d) Future Configurations of the Educational System

Educational systems in general do not seem ready to consider the long-term modifications implicit in the use of NIT and, in particular, do not seem particularly prepared to create or accept even partial alternatives to traditional schooling.

e) Curriculum Development

Different and sometimes alternative pedagogical strategies are used in introducing NIT in the curricula, e.g.:

-- Pervading all disciplines;

-- Focussing on informatics as a discipline;

-- Promoting the appreciation of the impact of NIT on society.

Some common trends:

i) NIT has initially emphasized facts and information. More emphasis needs to be given to intellectual processes based on problem identification and solving;

ii) Overlap between disciplines and interdisciplinary approaches to problems are increasing; the preservation of traditional boundaries between disciplines is no longer possible and the definition of new boundaries is difficult. Implied is the desirability of adopting an integrative approach to education, a strategy that is made easier by the computer's capacity to cope with complexity;

iii) Learning is considered as a lifelong process: the school cannot conclude the process of acquisition of knowledge and skills. The attention must shift to "learning to learn";

iv) Whether systems engage in general curricula reform or not, reform in specific vocations cannot be avoided because of NIT-induced modifications in industry (e.g. printing, banking, etc.);

v) NIT can help students to solve more complex problems and more real life problems because of the computer's capacity to provide access to extensive and diverse data bases together with the capability of manipulating, interpreting and understanding the complex issues involved. This democratisation of information makes an important contribution to values education;

vi) Negative effects of introducing NIT in education are possible and in particular:

-- Excessive interaction with a computer can be an artificial way to acquire knowledge and to have a contact with the real world;

-- Logical and algorithmic skills should be balanced with creative activities and divergent thinking.

f) Computer Science in the Curriculum

While it is generally accepted that all pupils at secondary level should become informed about informatics, neither the level at which the study should be introduced, nor its extent was considered. The importance of ensuring that knowledge of informatics was accessible to all equally was of prime importance.

g) The NIT as an aid to teaching

Teachers are central to the process of curricular innovation. Some conditions seem to be critical:

-- In-service training at all levels;

-- More collaboration between teachers, specially in planning activities;

-- Practical aids to teachers as counselling, assistance, maintenance of equipment;

-- Co-ordination and co-operation between teaching agencies at all levels.

h) The impact on the institution of education

-- Even if it is difficult to say how the traditional institutions will be modified in the long term, some tendencies appear to be evident and common:

i) Students will have greater scope to take control of the learning process and to negotiate it;

ii) The role of the teachers is likely to modify, emphasizing pedagogical management, learning integration and social and moral guidance.

-- A multiple-channel educational system, perhaps in competition with industry and informal education networks, is a perspective to be accepted. The school as institution can conserve its central position if it becomes more flexible.

-- The use of NIT in distance education provides scope for the individualisation and decentralisation of education and power for extending the range of education to all corners and all sectors of society.

RECOMMENDATIONS

a) Because effective use of NIT depends on effective research, it is recommended that support be given to research in curricular development, evaluation and implementation at the different levels, including further and higher education, but in particular within a framework that facilitates the international sharing of results. To this end, procedures for achieving syntheses of research findings are recommended.

b) For future action the following areas are suggested:

-- NIT in primary education;

-- Reconciling the differences between the traditional curricula and the NIT-based curricula;

-- Integration of NIT in different subjects;

-- Quality standards for educational software;

-- Approaches to teachers' training;

-- Societal implications.

c) Noting the conclusion in para. 51 of CERI/NT/84.09, that "Computer-related courses for both students and teachers lack attention to the societal implications of the NIT. Courses should include discussions of the human, ethical, political, and economic implications of the new information age.", it is recommended that attention be given to the study of this important issue.

d) The quality of the papers produced for the Conference and the opportunity the Conference offered for a general state-of-the-art review of NIT suggest that a regular procedure for review and up-dating of information would be most valuable.

Report from Working Group 4

NEW TEACHING FUNCTIONS AND RELATED TRAINING

President: Martyn Roebuck, United Kingdom
Rapporteur: Denis Healy, Ireland

New information technologies and the rate at which advances in them are accelerating pose many important problems and challenges for education systems. These have been presented with clarity in the documentation produced by the OECD Secretariat and their consultants. Working Group 4 found the document "New Teaching Functions and Implications for New Training Programmes (CERI/NT/84.08) by Rhys Gwyn particularly useful in their deliberations.

a) Teacher functions

The group considered that the role of the teacher will change significantly with the introduction of NIT into schools if the NIT are to have significant beneficial effects on the quality and efficiency of the education process. The teacher will be required to fulfil many, if not all, of his existing functions as well as additional functions. The successful use of NIT will have a liberalising effect and will enable a teacher to become a better teacher, a better facilitator of learning opportunities. The changes in teacher functions will be dependent to some extent on the expectations of educational authorities, teachers and society. These changes may differ significantly from country to country due to the effects of varying cultural influences.

In the absence of any hard data on teacher roles and expectations it was not possible to propose with any degree of certainty changes that will occur in teacher functions. However, the role of the teacher is considered to be crucial, and to continue to be so for many years, in ensuring that students are given basic understanding and skills to enable them to handle information, to critically analyse and evaluate it, to develop their decision-making skills and to improve their problem-solving capabilities. NIT can assist teachers in this task and teachers must use such tools given the changing demands of society and to prevent many students becoming alienated from the formal education system.

Concern was expressed for the need to explore ways in which schools are already changing and adapting to NIT and to study examples of the changing role of teachers in the context of cultural/structural expectations. It is suggested that such a study be undertaken by OECD in association with relevant teaching interests including teacher unions.

b) Co-ordinator

As highlighted in para. 27 of the issues paper (CERI/NT/84.11) and described in some detail in the expert paper (CERI/NT/84.08, para. 17-21), the concept of a "co-ordinator" has emerged. This post is seen to have at least three origins:

i) As part of a planned training process (a 2-stage or a "cascade" approach) with the co-ordinator based in a school with responsibility for both stimulating and co-ordinating the introduction of NIT content but also facilitating the use of NIT by a range of teachers of different subjects to support their own teaching;

ii) Covering a group of schools, perhaps within a school board, again as part of a planned provision; and,

iii) Emerging, nationally, mainly within individual schools, to meet a perceived need, perhaps eventually gaining formal recognition.

Clearly there are other possibilities. The conclusion was that this phenomenon be further studied.

c) Teacher Training

The group was conscious of the fundamental inter-relationship of hardware and software supply, curriculum change and teacher education and, while in some respects some members believed that the "panic" approach was unjustified, in general it was agreed that in-service teacher training was the area of greatest need, particularly in those countries with falling rolls. The form, the timescale and the organisation of in-service teacher training depended upon the perceived priority of this need, the extent to which there was any recruitment of teaching staff and whether pre-service and in-service was mandatory or voluntary.

Different approaches to in-service teacher training were referred to. The features discussed were:

i) Different forms of cascade, 2 or 3 stage approaches;

ii) The role of a "co-ordinator" or "animateur" in teacher education;

iii) The potential contribution of distance learning, as yet relatively untapped but of great interest;

iv) In-service training via curriculum change and the use of software as part of the teaching within a specific subject area -- promoted as a subject-based approach;

v) In-service training through centrally developed software, distributed without specific requirements linked to curricula or examinations; and

vi) In-service training through using commercial software.

Information is required on the experiences and effects of these approaches while at the same time it is clear that they have differential applicability depending on:

i) Whether the school system is centralised or de-centralised and in what respects;

ii) The level of education (for example a co-ordinator-based cascade process which is cost effective at secondary school level might be prohibitive at primary level; and

iii) The extent to which curriculum was uniform at either local or national level.

In addition, there is the issue of what the aims and objectives of the training are and whether it is on NIT or on the enhancement of teaching of all subjects using a range of approaches and devices, and how teachers who are "not interested" could be motivated and incorporated into training programmes.

The group requests that OECD in conjunction with Member countries, facilitate the exchange of information about these issues, perhaps by case studies or studies of the process of specific innovations with their strengths and weaknesses. Two possible approaches are suggested:

i) Assembling a data base incorporating basic data about courses (pre-service and in-service) covering duration and content;

ii) Developing specific evaluative case studies which focus on strategies detailing:

-- The aims of the courses;

-- The type of teacher and teacher trainer for whom they were intended;

-- The methods employed;

-- The model of the teacher assumed;

-- The factors which determined these characteristics.

The access to these studies and data base could be through an international centre or network for exchange of information referred to in para. 15.

d) Training of Teacher Trainers and School Management

It is considered that the training of teacher trainers was equally, if not more, important but the view expressed seemed to be that this was very much an issue for their own institutions, though approaches could be similar to some of those outlined above (para. 6). Evaluative case studies based on existing changes in teacher education provision and staffing is recommended as are means to encourage closer involvement of teacher education institutions with research relating to the applications of new technologies to learning and teaching.

In some countries a further need exists for the enhancement of the training of school principals and school management boards, where such training occurs. In these cases the role of the Principal/headteacher was considered central to the promotion of development in the school and it has to be supported. In other countries such a level of management training was distinctly not a need -- the question arises as to the point at which effective management of staff and resources should be supported by learning in these circumstances.

e) Support Structures

In certain countries support structures exist which are perhaps adequate for the dissemination of materials and for providing advice to teachers and school management on matters pertaining to the introduction and application of NIT to particular level(s) of education. However it was considered that in many countries additional support is required at primary and secondary level in this area. It was suggested that this could be provided by developing the use of existing formal national or regional networks such as teacher centres or by establishing new "ad hoc" structures in countries where structures such as teacher centres are not a feature of the education system. In establishing new structures and expanding existing systems for the dissemination and exchange of information it was suggested that use be made of electronic mailing systems.

It emerged that a number of countries have investigated various issues and formulated strategies relating to NIT in Education. Cooperation in this area between Member countries of OECD is desirable if not essential. It is recommended that the feasibility of establishing national centres for the exchange of information be explored by Member countries which currently do not have such a centre.

f) Cost

The impact of NIT on the quality of education appears to be much greater than would be expected from the incremental costs of providing basic hardware and associated software to schools. However in developing strategies for the introduction of NIT into education due cognisance must be taken of not only the initial equipment and courseware costs but also of recurrent maintenance costs and in-service teacher training costs. The latter cost is perhaps the greatest. In some countries the provision for in-service training of teachers is currently considered inadequate while in others it appears that no additional resources/finances are required.

g) Main Recommendations

The main recommendations of the Working Group are as follows:

i) A study of the changing role of teachers in the context of cultural/structural expectations be undertaken by OECD in association with the relevant teaching interests;

ii) The emerging roles and functions of the NIT co-ordinator be further studied;

iii) OECD in association with Member countries develop specific evaluative case studies on strategies relating both to teacher training and to the training of teacher educators;

iv) OECD in association with Member countries assemble a data base of basic data about pre-service and in-service teacher training programmes;

v) Access to OECD studies and data bases be given to interested parties through National Information Exchange Centres.

Report from Working Group 5

SOFTWARE AND COURSEWARE FOR A MULTIMEDIA EDUCATIONAL ENVIRONMENT

President: William Broderick, United Kingdom
Rapporteur: Raymond Morel, Switzerland

Professor Y. Le Corre introduced each specific topic. Work was in three phases:

i) Production of courseware

ii) Diffusion of courseware

iii) Research and prototype production.

I. MAIN CONCLUSIONS

A. PRODUCTION OF COURSEWARE

In taking stock of the present situation, the following subjects were discussed:

a) Hardware limitations

It is necessary to distinguish between the characteristics of systems designed for authors and those used by teachers and pupils; but clearly the first requirement is to know what will be taught. Hardware does not necessarily have to be specialised for education; nonetheless the problems of standardizing software developments are heavily dependent on the hardware available.

b) Target groups

A wide-ranging exchange of views showed that the methodology has to be differentiated according to type of CAI activity and target group. The existence of pre-tests or of a teaching model makes it possible to develop a number of prototypes; it is imperative to avoid the present wastage caused by many people developing the same products. The videodisc should not remain confined to industry, since it has been observed that it is often the youngest pupils who benefit most from it.

c) Courseware design

The production of courseware should not be left solely to a team of computer specialists; it is preferable to set up an interdisciplinary team of teachers, educational psychologists, computer specialists, and audio-visual and television specialists.

The debate between the proponents and opponents of authoring systems has yet to be settled (material for a workshop?), even if such systems hold out attractive opportunities for easy courseware modifications at several levels; this could moreover prove valuable in guarding against the dangers of imported culture.

Nonetheless all believe that it is essential to have software tools in order to design courseware.

In conclusion there was surprise at the intensive use of authoring systems in the private sector, by contrast with the lack of enthusiasm in education.

d) Improving courseware quality

The methodology commonly applied is the iterative approach. Tests and monitoring of pupils' responses are important and should form an integral part of the necessary software tools.

e) Co-operation within the educational system

Concerning the question of how teachers can be made to benefit from the knowledge accumulated to date, two distinct groups are involved:

i) New teachers who, it is recommended, should be shown prototypes of existing courseware, but here it is necessary to have a certain range in order to appraise different strategies.

ii) Experienced teachers, who derive great benefit from involvement with other teams (foreign or native) through exchanges of courseware, national or international meetings, joint projects and so on.

One way of exchanging output is through courseware libraries. The best courseware is generally that which offers many opportunities for exploration by pupils. The importance of teacher training in all disciplines was also emphasized as a means of facilitating this co-operation.

B. DIFFUSION OF COURSEWARE

In dealing with this topic, discussion focussed on:

i) Hardware portability;

ii) Software portability;

iii) The different ways of gaining access to courseware (identification, information on quality, thumbing through, courseware library, etc.);

iv) Protection of authors' and publishers' rights;

v) Use of courseware elsewhere than in the source country and safeguards against the dangers of imported culture.

As regards the whole set of problems underlying the topics discussed in the working group, a thorough reading of the background document (CERI/NT/84.05) is highly recommended in view of its outstanding quality

C. RESEARCH AND PROTOTYPE PRODUCTION

In-depth investigation of the topic cast fresh light on:

-- The subject matter to be taught;

-- The manner of teaching;

-- Difficulties in learning;

-- Difficulties in assessing pupils, or even a teacher's own performance.

After a tour de table, it became evident that current research exercises in these fields are both inadequate and too few in number, resources being very limited in most countries.

As a result of the discussions the Working Group strongly urges adoption of the following recommendations.

II. RECOMMANDATIONS

Preamble to Recommendation 1

There is a need felt by all Jurisdictions represented in the Group for more information to flow freely and frequently between Member countries about the introduction of new information technologies into education. This need is recognised to be significantly greater now than before.

Recommendation 1

That an International Centre be established to act as a focus for the exchange of information about the use of computers in schools and development and research on this subject.

Preamble to Recommendation 2

An International Centre needs an effective channel of communication to schools, colleges and universities in the countries embraced by the scheme. An effective network for gathering and disseminating information is vital to the success of an International Centre.

Recommendation 2

The International Centre proposed in Recommendation 1 should form strong links with nominated national centres which will in turn have responsibilities for providing effective channels of communication to schools, colleges and teacher training centres.

Preamble to Recommendation 3

If information about software and courseware is to be communicated between these centres then a common format for such communications is essential if the meaningfulness of such reports are to be really understood. A set of standards is necessary and could be developed upon a schema based upon that developed in Ontario, Canada.

Recommendation 3

A uniform standard for cataloguing, describing and evaluating software and courseware should be established.

Preamble to Recommendation 4

The successful interchange of information about software will lead inexorably to the need to exchange software. The latter need may well exist independently of the suggested precondition. There are already successful projects that allow the interchange of software between enthusiasts using radio and TV technologies.

Recommendation 4

Internationally recognised standards are needed in the fields of authoring systems, software toois and graphics. It is recognised that this list may need to increase. A working group should be established to specify and make known these requirements to support the transportability of software between members.

Preamble to Recommendation 5

Discussion throughout the group illustrated that whilst there was a diverse set of views about the style and content for research in this area it was recognised and strongly recommended that additional support should be provided for both pure and applied research in this area in Member countries.

Recommendation 5

That co-operative research projects be established in Member countries to support the development and understanding of the role of the computer in education.

Conclusions of the General Rapporteur,
Professor Gilbert de Landsheere,
Director, Laboratory of Experimental Pedagogy,
University of Liège, Belgium

INTRODUCTION

Anyone who is involved with new technologies tends to get somewhat tired of conferences, symposia, seminars, workshops and similar gatherings where he is by turns a speaker and merely a patient listener to much that is borrowed, banal or repetitive.

So it is with particular pleasure that I would like to begin by paying tribute to the Director, J.R. Gass, his colleague G. Papadopoulos and their outstanding team at CERI for this Conference. Having been exceedingly carefully prepared with the collaboration of eminent specialists, it has enabled us to take stock at a decisive juncture. When reading the remarkable preparatory papers and subsequently during the work of the Conference, we have all, I think, felt that we were learning a great deal.

It is much to CERI's credit that, since its inception, it has taken upon itself to address some of the most important problems in the field of education and has prepared the way for their solution. Since decision makers pay great heed to CERI, it has thus been at the origin of change in a number of the aspects of education and it is now assured of a place in its history.

It has been pointed out than during this Conference, discussion of the new information technologies seemed often to be confined to computers and computer-assisted instruction (CAI) -- a term which, as Yves Le Corre suggests, needs to be interpreted in its broadest sense. There is some truth in this, but I think this is quite understandable since currently it is this that poses the most direct challenges to education in all its aspects and raises the most urgent problems. This same bias will be found in this report, which does not at all mean that other information technologies (which, moreover, themselves contain a computer element) have been underrated and ignored -- far from it.

One final introductory remark: your rapporteur has carefully noted all the interesting ideas contained in the conference documents or mentioned during the discussions, and a number of other important aspects have been raised in the Working Groups' conclusions and recommendations.

The half hour that has been allotted to me would not suffice even just to read out this list of interesting ideas one after the other without comment. This is why I have taken the risk of setting this aside, selecting one or two major themes and highlighting a number of fundamental ideas put forward in the documents or during the discussions.

One significant fact that has emerged is that attitudes to the new information technologies differ enormously not only from one country to another but sometimes also within the same country. Another thing is that where these new technologies have actually begun to be employed, there are no longer any of the deep-seated fears common to many of those who have yet to make this initial decision. On the other hand, there are still problems and questions that everyone is having to face.

Howeer, during the Conference, there was one point on which there was complete unanimity: the desire for close international co-operation with the help of the OECD.

But, to turn our attention more specifically to the aims of this Conference, these were to:

i) Review and discuss the results of the work undertaken during Phase I of the project on "Education and New Information Technologies" -- a phase of information and clarification;

ii) Develop a number of proposals for concrete action for implementation in Phase II -- the action phase.

Phase I of the project, which has just come to an end, has obviously been carried out successfully and, as of now, there is no lack of proposals for future action. As we shall see, some of these are of vital importance.

Education and Society

History has shown that the ideal where man and society are continually moving forward, albeit at a different pace, towards a better future bears no relation to reality. Not only are civilisations mortal -- as has been said so often since the time of Valéry -- but they can also stagnate or regress.

The institutions and practices of education are determined primarily not by our ideal conception of man nor our psychological and pedagogical knowledge, but rather by the nature and level of economic development and its related social phenomena.

As early as the beginning of this century, Durkheim wrote that the man that education must fashion within us is not an abstract, ideal man, a human being as viewed through an eternal philosophy, but a man as society wants him to be and society wants him to fit the requirements of its inner structure and organisation. And it is precisely by virtue of this axiom that the introduction of new technologies into education seems unavoidable.

Even in the inaugural speech by the Honorable Bette Stephenson, Chairman of this Conference, a very understandable doubt was expressed: was not computer-assisted instruction merely another new fashion like so many others in education; would it not soon be regarded as just another passing phase? Was it not being said in 1960 that programmed instruction was the most important innovation in education of the 20th Century?

In reality, the situation is radically different: whereas programmed instruction, irrespective of its significance, was a phenomenon virtually confined to education, the new technologies are a phenomenon of society or, if you prefer, of civilisation -- in which case, education in all its forms clearly cannot escape it.

It will have even less chance of escaping it since one of the aims of this society is to ensure equal opportunity as regards education and, as Peter Bollerslev has pointed out, these new technologies extend this equal opportunity to groups that hitherto have been far from able to enjoy it: the socially disadvantaged and those that are handicapped, whether physically, mentally, culturally or geographically. For these, probably more than any others, distance teaching will play a fundamental role.

The reason why I have allowed myself this brief restatement of the issue, despite the little time available to me, was in order to emphasize an idea expressed in a variety of ways during this conference: these new technologies have already been introduced into education, in some cases in a planned manner and in others somewhat haphazardly. What is important now is to control the process so that it can be of genuine use, rather than possible harm, to education.

However, let it be said once again, in the last analysis it will only be possible to find answers to the questions that concern us if we are aware of what society is like today and what it will be like in the future.

The optimistic hypothesis is that, as a result of technical progress, man will be less and less obliged to devote himself to work and, should he so wish, will no longer need to organise his life around it. For some, work will become a fringe activity in relation to their aim in life and also in relation to the type of studies they will have done -- no longer with a particular job in mind but rather to satisfy their own tastes and aspirations.

The inevitable redistribution of wealth and income that will be necessary in such a society will be accepted only if the "losses" that some will have to agree to are offset by a real improvement in the quality of individual and community life. Only in a humanist, pluralist society based on the principle of democratic participation will it be possible to achieve such an aim.

Education

What sort of educational policy ought one to adopt when introducing new information technologies: tackle the system as a whole or, as some countries are doing, begin with vocational training or secondary education? It would seem that this decision will sometimes, if not often, be determined by non-educational considerations.

Ideally, it would obviously be preferable to tackle the system as a whole -- which does not mean that everything has to be done at once (even if this were possible). However, this is not to say that, over the medium and long term, assigning priority to pre-primary and primary education might produce the greatest economic and social benefit in the form of a dramatic increase in the emotional and cognitive effectiveness of schools. It is a well-known fact that, in the case of many children, under-achievement starts in a manner that is difficult to reverse from the outset of their school career. Independent observation as well as the more systematic surveys that are becoming available indicate that computer-assisted instruction can provide a real means of salvation for many of these pupils.

Will social pressure, however favourable, generate swift and full acceptance of these new technologies? Obviously, they can only be of real interest to us if, instead of contributing yet another useful but peripheral technique, they result in a marked qualitative and quantitative improvement.

This fundamental improvement would seem to a large extent to derive from greater flexibility in methods of education and in access to information. In this connection, it would seem that the determining factors are the individualisation or semi-individualisation of the learning process and, more generally, the scope for independent work.

In this same context, an outstanding report by the Secretariat on learning processes contains a phrase to the effect that the computer can restore to the teacher his true role, i.e. demonstrating to the pupil how he can do without him.

It can also be argued, as does another of the Secretariat's reports, that the new technologies will enable mass education to benefit from the most advanced educational ideas.

In my view, the key question is the following: well before the advent of the microprocessor, there were proven methods already available to schools which, combined with the contributions from research in psychology and education sciences, would have made significant progress possible many years ago. Why did this progress not occur? Why would it occur today?

To take one or two examples: since the beginning of the 20th Century, various systems of individualised instruction had been invented and tried out with success, such as the Winnetka Plan, which was fully operational by the 1920s, or the Keller Plan, directly based on contemporary neo-behaviourism. In addition, the so-called mastery learning method, which makes full use of the widest variety of human interactions and technical resources, has by now proved its worth. Why therefore the delay in putting these plans, these methods into practice?

I would therefore qualify somewhat one of the basic conclusions of the 1970 CERI Seminar in Portland, USA, where it was said with remarkable perception that computer-assisted instruction had unfortunately inherited all of the pedagogical problems and had brought them into sharp focus like a microscope, demonstrating that the essential conceptual resources needed to launch a vast and meaningful pedagogical undertaking were purely and simply non-existent.

It is undeniable that computer-assisted instruction highlights all these defects and moreover this is the reason why CAI provides education with the opportunity to make a major step forward. On the other hand, even in 1970 and still less today, to say that the conceptual resources are non-existent is not quite true. Many do exist but continue to be disregarded. Properly used, they could have long since changed the face of education.

The reasons for this resistance to innovation are legion and have for many years been the concern of CERI and many other organisations and specialists. This is why I shall be concentrating here on just one highly significant factor: the personality and the training of teachers.

At present, this training is inadequate in terms of its content and perhaps even more so in terms of its methods. How can it be credible and effective if it advocates practices that it does not employ itself? It is not by means of conventional classroom teaching that trainee teachers can be taught not to use conventional teaching methods. So, if teachers are to be made receptive to new technologies, then the first priority is not to train them in the use of computers but with the use of computers.

The methods that teachers use are governed by beliefs and attitudes that have been deeply and unconsciously absorbed during their school career, which in some countries begins at the age of three in the case of more than 90 per cent of children and thus lasts at least 15 years up to the end of compulsory education. That is why, when they themselves become teachers, they tend to copy the teaching techniques that were used when they were at school and not the techniques advocated by more recent teaching theory.

Before training anyone to use these new technologies or, more accurately, concurrently with this training, the underlying attitudes and habits of educational practice need to be thoroughly reformed. This will be a complex and costly operation and will only be achieved by working together with the teachers over a long period of time and by endeavouring to resolve jointly the problems that they have decided to tackle.

The area of greatest priority, as Group 4 emphasized, is the in-service training of teachers, many of whom will still be teaching in the year 2000. In particular, much tact and astuteness will be required to overcome the almost instinctive resistance of some of them to the new technologies.

It is obviously much more easy to perform this operation during pre-service training providing that the teachers' instructors have themselves been appropriately retrained. If such action is not taken, then education's great leap forward is not going to happen in the immediate future.

All this is going to cost a lot of money because, in order to go beyond the critical threshold below which the effects of these training and retraining operations will not make themselves felt throughout the system as a whole, this action will need to involve hundreds of thousands of educators.

What is more, if we succeed in bringing about a change in the teaching profession, its status will thereby be enhanced and, as J.C. Eicher points out, this is bound to be followed by further wage demands. At present, the attitudes of the unions differ; but it would not do to ignore the unions or, for that matter, any of the other social partners.

A Change in the Nature of the Problem

There was much discussion during the Conference on the subject of hardware from the point of view of its nature, price and capabilities. We were given much invaluable information. No-one here underestimates the importance of the hardware and software. However, in my view, a new and decisive factor is beginning to emerge: in the field of computer-assisted instruction the problem for a time is going to switch from being one primarily involving the computer, i.e. the hardware and software to one involving the instruction, i.e. the courseware and its use.

In recent years, microcomputers have been developing so fast that they became outdated in a matter of months. Schools moreover, because of the cost constraint, in many cases acquired low-performance equipment that ruled out the use of complex courseware and even more its production -- which meant that the teaching approach was subject to the capabilities of the computer.

However, this situation is changing radically as relatively cheap 16-bit, 256 or even 512-K microcomputers become available (prices are remaining stable whereas quality is improving). With this amount of memory and speed of operation, schools will be able for many years to come to do virtually anything they want. I regard this progress as being rather like someone who, after having a bicycle, a moped and then a motorcycle, becomes one day the owner of a decent motorcar, which satisfies all of his requirements so that he feels no immediate need for a more powerful vehicle. Now, for the first time, the same is going to be true for microcomputers.

The next major and urgent step is to find simple and inexpensive ways of adding sound and graphics so that the teacher can, when he wishes, insert his own material. Once this is possible, computer-assisted instruction will have come of age. In my opinion, however, we shall have to wait a few years for this.

What is more, it is certain that the problem of programming language as such will soon cease to exist. Despite the slight differences of opinion that exist on this subject -- Y. Le Corre has made a good analysis of these -- there is no doubt that authoring languages close to natural language will soon be available (which does not mean that there will no longer be any need to worry about the logic of programs -- this will then be the main problem).

The elimination of the problem of hardware and software will mean that efforts can be concentrated on the production of quality and possibly highly complex courseware and its use. In short, the means will rightly assume a secondary role and allow the emphasis to be placed on the ends.

In some ways, therefore, I am in complete agreement with Joseph Weizenbaum's way of thinking: for the teacher who is preparing a CAI lesson, the computer should be symbolically invisible so that all his attention can be directed to the content to be got across and on the best way of doing this.

What has been said so far has concerned the qualitative aspect of computers. There is still the question as to whether it will soon be possible to equip all educational establishments with a sufficient number of them. It would appear that this is far from the case.

Unless there are some new and unforeseen developments, it looks as if it will be more than a decade before schools are fully equipped, even in a country like France, which made a very early start in this field.

If we accept A. Melmed's principle that every pupil in a school should be able to use the computer for at least 20 minutes a day, we can work out, as Eicher has done, that, even if France achieves its target of 100 000 microcomputers by 1988, it will still be 600 000 short of Melmed's guideline. What is more, there is an even greater lack of peripherals and the cost of maintenance seems to be outstripping the depreciation on the equipment.

The cost of converting premises, furniture, etc., has also to be considered.

Very soon some agonizing decisions will have to be taken both in the rich and, more particularly, in the poorer countries, because undoubtedly it will be necessary to allocate investment to particular sectors or segments of the population in preference to others.

Courseware

Let me begin by the saying that I use the terms computer-assisted instruction (CAI) and courseware in the broadest sense as defined by Y. Le Corre.

It has been proved -- if ever there was any doubt about it -- that, currently, creating courseware packages of satisfactory quality and in sufficient quantity is a more difficult task to achieve than creating sophisticated hardware.

It is impossible not to agree with Giovvanni Larricia when he inveighs against the error of thinking that the use of new technologies necessarily implies an advance in education. In many instances, CAI has led to a decline. Every week we are confronted with courseware packages created by specialists with no psychological or pedagogical training who seem to think that putting material onto a computer *ipso facto* endows it with an educational value whereas, without realising it, they are reinventing Herbart.

Moreover, there is the question that Pamela Christoffel raised: will what is quality courseware for one group be quality courseware for another?

This is a question that can and should be widened, as was done by Portugal's Secretary of State, Mrs. H. Carvalho Santos, when she raised the problem of culture and national identity.

Courseware packages cannot, any more than tests, be culturally neutral -- hence the major constraints on transportability between educational systems. A more logical proposition would seem to be to transfer cores that can be incorporated into other contexts. Group 1 rightly recommends that the necessary tools for producing quality courseware should be exchanged rather than the courseware itself, although naturally the one should not exclude the other, depending on which is likely to be of greater benefit.

Similarly, there is a tendency to forget that courseware is not psychologically neutral. Each individual has his own dominant motivational drive and cognitive style; whereas one will go from the particular to the general, another will proceed in the opposite manner.

Presumably, when a quality software package is put on the market, the implicit assumption is that it is suitable for all those belonging to the same age group, culture, etc. But this is not so and there have been no instances so far of the same basic courseware being designed in several forms to match the different cognitive styles of different pupils.

The Preparation of Complex Courseware

Under the heading of "simple courseware" we would include programs of practical exercises and applications, simple simulations, etc., whereas by "complex courseware" we mean complete learning packages including ideally a test of background knowledge, a pre-test, the instructional unit per se (analysis of the subject matter, practical exercises, comprehension test, corrective procedures) and a post-test.

There is still a dearth of good courseware packages of this type, since they require a considerable investment in terms of talent, time and money. However, they are an ideal means of pedagogical progress.

Why? Because, having decided on the value of dealing with a particular subject matter, there are four major and equally difficult phases that have to be gone through:

i) Preparation of the subject matter;

ii) Definition of a teaching methodology and a learning strategy;

iii) The actual writing of the program;

iv) Testing the sequence and checking its quality.

Preparation of the Subject Matter

One particular phenomenon is consistently highlighted by the process of devising programmed pencil and paper courses and courseware in collaboration with highly qualified teachers: as soon as one starts programming a subject matter, however simple it may seem, gaps are revealed in our knowledge of it -- frequently much of the time is spent overcoming this initial problem.

As J. Fourastié has so rightly said, the computer is both the slave and the master of the thinking process. It needs only the slightest defect in the instructions it is given to make it go astray and produce nonsense. Unfortunately, our knowledge is not without its gaps. In some instances we may not be aware of them and in others, while we may recognise that they exist, we find a way of shifting onto what at least appears to be safer ground, seeking consolation or an excuse in the fact that, in any case, one cannot be expected to teach everything.

The teacher with his heavy daily workload cannot rethink everything from zero. He relies on reference works and textbooks that he trusts. Although not slavishly following their method, he will often derive from them his approach to the objectives he wishes to achieve. A lesson prepared in this way becomes a personal instrument used in the particular dialogue between one teacher and his pupils.

With the preparation of a CAI sequence, the situation changes radically, particularly in the case that concerns us. It is a question of creating a product that can be as widely used as a textbook and if in addition it includes procedures to monitor the learning processes, its effectiveness will be put to the test virtually at each stage.

As soon as one begins to delve into a problem, one becomes more and more aware of the differences between writers of textbooks and between specialists, and of the difficulty of extracting a hard core of what might be called today basic skills -- in short, to differentiate between the essential and the non-essential. And then again, simple, clear rules need to be formulated to which, if possible, there are no exceptions. The number of questions starts to increase, as do the occasions for argument. In the end, even what has always been taken for granted will in some cases start to look like no more than the fortuitous success of some author's dogmatic opinion.

The first major benefit from the development of CAI is a further refinement of subject matters -- an increase, as it were, in the capital assets of education. Even if there is nothing final about them, such improvements are valuable.

Having gone through this initial phase, the next step is an overall discussion of the methodology. What fundamental teaching approaches should be adopted? Subject-centred or pupil-centred instruction? The build-up of knowledge as advocated by Piaget or the imposition of "prefabricated" knowledge? Learning without error in the Skinnerian manner or the progressive discovery of rules at the risk of making mistakes? Concentration on instrumental knowledge or not? Acquisition of knowledge in the form of a patchwork or a sequence governed by aprioristic principles? Use of examples from everyday life to the exclusion of any imaginary cases to prove a point? A modular approach based on the main cognitive styles or a unified approach?

There is no limit to the number of such questions and some the experienced educator will find impossible to avoid.

The answers in any case will come from the strict testing of the sequences produced. This testing in turn raises several problems. How should it be designed? What method should be borrowed or invented to assess background knowledge, how much is already known (the pre-test), the intermediate stages and the final result (post-test)? How should the gain be assessed? How should the tests be phased in the case of learning difficulties or failure? What corrective loops or sequences need to be provided?

This strictness in checking and assisting learning processes is also a source of progress.

At last, the computerisation stage is reached. The subject matter has been agreed, the teaching approaches decided and perhaps even the scenario devised. The necessary algorithms have been constructed.

The next question is what hardware and what programming language should be used?

When all this has been done, all that remains will be the testing and checking of quality.

I think the utmost importance should be paid to the standpoint adopted by Y. Le Corre and Jacob Schwartz; Let me quote them at somewhat greater length:

"Emphasis on today's machines is a very poor way of exploring the true potential of CAI technology. To prepare for the possibilities that the next few years will open up, we need to "lead" the rapidly moving hardware "target" substantially by writing software and creating courseware not for today's machines, but for systems that will be typical five years or a decade from now. It must nevertheless be borne in mind that today we are far from exploiting all the possibilities of existing personal computers, even when the educational packages for which they are provided have been produced on much more powerful computers. We also need to take educational software very seriously and strive to create "classics" which can be used for years in the future by people of very different training backgrounds, ages and motivation, differences that will have to be properly reflected in the way the package converses with its users."

Experience has shown that preparing one hour of complex courseware involves a considerable outlay (some very revealing figures are quoted in the preparatory reports), which is virtually never recouped by the producer, because his product is immediately pirated and for this there is no effective remedy.

The consequences are there for all to see: the demand for quality complex courseware is enormous, but those who can and want to produce it, whether they be research laboratories or commercial firms, are giving up one after the other.

The only solution that I can see is for the various countries to set up public agencies to produce this type of courseware (I use this general term "public agencies" deliberately since such agencies can be organised along different lines. I prefer the decentralized variety that permit maximum interaction between teachers/instructors and existing educational research and development services). If these courseware packages are then marketed widely in the producer country and either exchanged between the richer countries for others (that are subsequently adapted) or simply made available to the less wealthy countries, possibly assisting them to make the necessary adaptations, this would represent an insignificant per capita expenditure and be of the utmost benefit to education.

Research

It is generally agreed that virtually none of the different current or forthcoming applications of new information technologies to education is based on proven research findings. Moreover, it would seem that not everyone is convinced of the need for preliminary scientific research. Group 2 in particular noted a certain lack of communication between researchers and decision-makers.

However, as was admirably highlighted in a report by the Secretariat, there is an abundance of problems and unknowns with regard to methods of learning, the effect of the use of these new technologies on cognitive and emotional development, the emergence of new learning processes, the genuine feasibility and conditions for a transfer of learning processes, the construction of curricula from nursery school up to university, the controlled experimentation of teaching strategies, etc.

Let me quote a few examples.

Will the use of these new technologies help to further our knowledge of the processes of learning?

The use of a computer is supposed to develop problem-solving ability, powers of analysis and creativity. Are we not here attributing to a new technology the merits that used to be ascribed to the learning of classical languages or mathematics? Is the longer attention span that has often been noted in the case of CAI likely to be a permanent factor?

Is not an intense involvement with information technology from a very early age likely to have adverse effects?

Group 3 came to the conclusion that it was necessary to rethink every curriculum in relation to what these new technologies could contribute. But have we already mastered a truly scientific method of building curricula? Are the new technologies, as some hope, going to result in a significant advance in the practice of interdisciplinarity?

Will the use of the new technologies be of equal benefit to everyone? Will it not tend to make the best students even better than the others? Or alternatively will there be a levelling upwards of intellectual development -- at least to some extent?

The LOGO environment is now in use worldwide; it has stimulated great expectations and enthusiasm but, to my knowledge, there have been as yet no consistent educational plans or programs that have been tested over a sufficiently long period of time to enable an assessment to be made of its true contribution, its specific place in the educational process, its limits and its possible drawbacks.

With these new information technologies are we going to repeat what can only be described as the gamble that was taken with the set theory or generative grammar which were widely introduced into school curricula without adequate preliminary testing and which is now leading to agonising re-appraisals that might well have been avoided? Unfortunately, in the case of the new technologies it would seem that the stakes are even higher.

In my view, a dramatic situation is in the making. Nowadays, a researcher has little difficulty in obtainng funds for a one-off research project or for a survey covering at most two or three years. But try obtaining guaranteed funding for an experimental longitudinal survey lasting 15 years! The figure of 15 has not simply been picked out of the air: it corresponds to the six years in primary education, the six in secondary education plus the first two years of higher education during which one would need to monitor an initial cohort, ideally followed by others.

This illogical state of affairs is likely to make us seem rather frivolous in the eyes of history: it has often been said that the advent of these new technologies and the computer in particular marks the third turning point in the technological and cultural history of mankind, on a par with the invention of writing and the invention of the printing press.

Our civilisatio [illegible] terms of science the farthest advanced of any, but those who possess the decision-making power -- be they public or private authorities -- do not seem instantly to grasp the fact that entering into a new era for mankind that will probably last several centuries certainly warrants 20 or 30 years of sustained research in the field of human sciences.

There can indeed be no question of halting the course of events; even if we wanted to we would be overtaken by their inexorable force. But it is up to us to behave like educated men intent on preparing as carefully and as scientifically as possible the first steps towards a civilisation where man must perforce remain the measure of all things. It imperative that our thoughts and our critical faculties should be directed to the situation taking shape before our eyes, which represents potentially an unprecedented advance.

CONCLUSIONS

Education, with or without these new technologies, can never be considered in the abstract, because the learning process does not take place in a social vacuum.

In the end, what criteria will govern the choices that have to be made, the decisions that have to be taken? Who will decide and who will apply them?

In the last analysis, it is once again the whole problem of democracy or the absence thereof that is being posed, but this time in a dramatic fashion in the face of a new and gigantic force.

There is talk in the United States of a possible educational revival. I think that the opportunity does in fact exist, but it has to be seized. In particular it is conceivable that if the school, through inertia, fails to operate the necessary change, education will in the end be transferred to other agencies or other institutional forms.

In any case, it is now an accepted fact that the traditional school has lost its monopoly of education.

Closing Remarks by the President,
Mr. John R Steinle,
Director General of Education,
South Australia.

Thank you, Professor de Landsheere, for your synthesis and conclusions. You have not only brought together the comments made in the papers and the speeches, but taken us beyond them.

I am glad that you referred to the timing of the Conference, it was indeed appropriate.

I am glad, too, that you took us back to the beginning of the Conference and the opening remarks of the President, the Hon. Bette Stephenson who, in her inaugural address touched on the themes of her optimism for the new information technologies, the need for co-operation between countries in their introduction of these technologies and the need for future directions to be expressed in precise terms.

In order to do this, she reminded us that we needed to make our objectives clear, to determine definite strategies and to state clearly the directions in which we should be heading.

We have done each of these things.

We have re-examined our objectives and we shall leave the Conference in the knowledge that we are in a position akin to that of Gutenberg. We have devices at our command which we are keen to see used and which we are confident will prove useful. We are not at all sure, however, where they will take those at whose disposal they are to be placed.

Even those countries which have gone the furthest in their adoption of the new technologies and who have developed and begun to implement comprehensive plans, have chartered their courses largely as acts of faith.

In terms of strategies, there appears to be a surprising degree of consistency among Member countries. There seems to be general agreement that the new information technologies present educators with fairly clear options.

The first option is to reject the NIT or to make superficial and ineffective use of them as we have done with earlier educational technologies. This, of course, does not mean that we can ignore them as they are changing our societies profoundly, and as the reflector and transmitter of the cultures of our societies, educators must recognise them and decide only upon their use.

The second option is to accept the NIT uncritically as aids at a time when education is under a cloud. Such a course is enticing as it promises renewal of the curriculum, the removal of the drudgery from much of school teaching and learning, and offers us the prospect of placing the world's storehouse of knowledge in every classroom.

But these advantages are, as yet, promises. They are uncertain and untested.

The third option which presents itself is for us to accept the new technologies critically as offering us assistance in our efforts to achieve our educational goals.

It is this position that seems to have been generally accepted by the Conference.

Thus the real choices for education remain the same as ever. They are choices among values: what knowledge is worthwhile, what constitutes a good person and what constitutes a good society? These are the fundamental questions which every country must decide for itself with or without the new information technologies.

Yet, in facing these choices we can still welcome the enormous increases in potential for ways of reaching our goals for they offer new ways and means of delivering education at a time when they are sorely needed.

They cannot, however, replace the human relationships which are at the heart of real education.

Most countries seem to agree with this, and are now endeavouring to decide the speed at which they should proceed.

Which brings us to the question of what OECD should do now.

Many questions have been posed and discussed. They fall into three broad categories:

i) Research

What do we really know about the impact of new information technologies upon learners and what are we doing to find out? How can we co-operate in finding answers to these questions? We take note of Professor de Landsheere's plea for a long term study.

ii) The provision of NIT

In general there seems to be agreement that commercial and social forces will take care of the provision of hardware with some support from the education sector.

Most frequently, concern was expressed over the availability of sufficient software of good quality.

iii) Co-operation

Given the inevitable and proper concerns of each country for its own culture, there is considerable support for seeking opportunities to share knowledge and experience.

Thus, in short, and contrary to popular belief, it is probable that the rate of developments in the use of the NIT will depend not only upon the availability of machines, but upon the availability of people and knowledge. So in introoducing technologies which are devoted to assisting in the ordering of knowledge and making it accessible to more and more people, it is a nice irony that among our first priorities should be the need to seek knowledge.

The second irony is that this introduction can only proceed successfully if we can prepare, and provide support and resources to, truly creative, sensitive and well motivated people.

In conclusion then we are resolved that the Secretariat should explore new modes of information exchange and corporative developments. This will also involve all countries in seeking to ensure that machinery is available for this material to be collected and collated at the national level.

It means too that Member countries will need to support OECD in this difficult task. As we have been reminded, all new and worthwhile innovations have required resources and they have meant challenges to existing structures.

There has been some suggestion that new machinery is necessary for this purpose, but wisely, in my view, this has been rejected in favour of using existing OECD machinery.

I therefore invite you to encourage your governments to lend support to whatever steps are finally decided upon by OECD.

I believe that in this case, time is not on our side and that we need to move forward boldly and quickly together.

To the Secretariat, I invite you to seek ways to disseminate as widely as possible the splendid material which was prepared for the use of participants at this conference.

Furthermore, I believe that this project could well be given the same priority that it is currently being given by industry, by commerce, by governments, by educational systems and by the schools of the Member countries.

Finally, I thank all who worked so hard to make this conference a success, the Secretariat, the Chairman, the rapporteurs, the speakers, the translators and those who prepared papers.

Thank you.

ORGANISATION FOR ECONOMIC
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THE INTRODUCTION OF THE NEW INFORMATION TECHNOLOGIES IN EDUCATION: POLICY TRENDS AND DEVELOPMENTS IN MEMBER COUNTRIES

The attached document has been prepared by the Secretariat. It will serve as a background report for the Plenary Session on Theme I (General Policies and Trends) and for the Working Groups 1, 3 and 4.

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Annex: AN OVERVIEW OF THE INTRODUCTION OF THE NIT IN MEMBER COUNTRIES: PRIMARY AND SECONDARY EDUCATION

INTRODUCTION

1. In November 1981, the Governing Board of CERI agreed that a project be carried out aiming at analysing the introduction of the new information technologies in education. Part of the agreed project proposal concerned analysis of the actions taken in Member countries at the policy level and the developments therein.

2. To achieve this objective, the Secretariat has gathered a body of information through a questionnaire (CERI/NT/82.01), submitted to the education authorities in Member countries in May 1982. Their response, updated a first time in October 1983 and a second time in March 1984, constitutes the bulk of the data on which the present report is based.

3. The questionnaire covered the various parts of the educational system, from primary to higher education. On the suggestion of the Advisory Group to the project, however, the response to the sections on Primary and Secondary education was made compulsory, while the section covering adult and higher education was left as optional. Given the gap in the countries' responses (many more replied to the compulsory than to the option part) and in order to ensure an even data base throughout the analysis, this report considers only the primary and secondary educational levels. The responses to the optional part are analysed separately (CERI/NT/84.03).

4. This report is divided into two main parts. The first part (An Analysis of Current Developments) gives an analysis of the situation, in three subsequent chapters. Starting, as it were, at the top of the processes under consideration, the first chapter analyses the major policy developments in a number of Member countries, the working hypothesis therein, the objectives, the priorities stated and the scales of investments established.

5. The second section looks at the strategies adopted to implement the policies, or, in the absence of explicit policy decisions, analyses the strategies of the introduction of the NIT in education which have emerged "spontaneously" given the institutional structures, the expertise, the motivation and the pressures existing in the countries. The themes of organisation, assessment and control of the process are analysed here. Additionally, this chapter analyses the reflection of policies and implementation strategies at the grassroot level - in the classroom. Quite obviously this chapter considers questions of curriculum change and development as well as the response of the main partners concerned: the teachers and the pupils. The familiar debate on the place of informatics in the curriculum, of its role in the teaching/learning process, and of the needs of teachers and pupils has a place in this chapter.

6. The last section endeavours to pull the threads of the analyses together and highlights its most meaningful parts. This section, therefore, deals mainly with emerging trends and conclusions. A set of consequent questions for the policy agenda closes the section as well as the report.

7. The second part (Annex: An Overview of the Introduction of the NIT in Member Countries: Primary and Secondary Education) depicts the situation in Member countries. It gives for each of them, a rapid overview of the most salient events of the recent past; a detailed account of the present developments; and an outline of some meaningful trends for the near future.

8. A final, and important, remark to make before embarking on the main body of the text concerns the validity of the analysis presented here. The methodological challenge of international studies is magnified here by the very characteristics of the material analysed, which is not only highly complex (as in most analyses) but also changing at an exceedingly fast pace. The ensuing considerations have therefore to be considered as indicative rather than conclusive, as relative and temporary rather than absolute or stable.

AN ANALYSIS OF CURRENT DEVELOPMENTS

Chapter I

POLICY ISSUES: OBJECTIVES, PRIORITIES AND SCALE OF INVESTMENTS

9. By early 1983, virtually all OECD Member countries had engaged in policy and development actions aiming at introducing the new information technologies in education.

10. Although similar in their broad underlying principles, the specific forms taken by the new initiatives vary across countries. The specific policy approaches adopted are different as well as the definitions of the scope and the nature of the technologies in education, of the roles and responsibilities of the educational institutions in charge, of the optimal target groups in the school population, of the most appropriate curricular innovations and of the human and material resources needed.

11. This chapter will endeavour to explore the reasons for the gap existing between common broad principles and separate detailed practices by charting some of the pressures and forces which underlie the commonalities among countries and those which determine their differences. The analysis will then consider the policy approaches developed, the priorities established, the scale of investments adopted, as well as the interplay between "official" and "spontaneous" educational developments. These elements of information will outline the broad pattern of policy and institutional constraints against which to evaluate -- in the subsequent chapter -- the current strategies of implementation.

12. The demand for the introduction of the new information technologies in education was already present in a restricted number of OECD Member countries since the early 70s. By the end of the decade it had spread to the majority of them, and has not ceased to increase since.

13. With the acceleration, the trend has also undergone a qualitative change. Ten years ago, the forces underlying the technological demands for education were essentially educational. At present they have multiplied to include pressures often foreign to education. These pressures come essentially from:

i) The evolution of the economy, in particular its restructuring under the effect of technology;

ii) The penetration of the technologies in all spheres of society;

iii) The evolution of policy concerns over the making of political supremacy in a technological world, the imperatives of international trade, the revived concern on the advancement of the natural sciences, thus on the role of education in developing the potential in the population;

iv) Evolution of the function and (increased) responsibilities of education with respect to the labour market, especially under the impact of youth unemployment;

v) The evolution of the educational technologies themselves towards increased differentiation and specialisation and reduced prize and size;

vi) The emergence of a (sometimes blind) constituency in favour of the introduction of the NIT in education.

14. Currently, these developments, common to most OECD countries, have converged to pressure education towards objectives that are not necessarily compatible nor complementary to one another, such as to introduce the NIT in education:

i) Where it is most needed for the needs of the economy:

-- To produce specialised manpower;

-- To develop a market for the national (multinational) electronic industry.

ii) Where it is most needed to prepare the young to be functional in a society premeated with the new information technologies;

iii) Where it is most needed for the functioning of education:

-- To subvene to the failures of the system, for instance with the low achievers or the gifted;

-- To improve the efficiency of the educational system in general;

-- To reduce its costs (with or without improving its efficiency).

iv) Where it is most needed for political visibility, i.e. to build a public image of governments changing the schools to the new image of the world.

15. Taken separately, each one of such pressure has clear -- and different -- implications for educational policies, on the targetting of the policies on specific educational sectors and population groups, on the scale of investments, on the equipment policies developed, on the curricular changes introduced and on the demands on the teaching staff.

16. If the pattern of pressures is rather similar across countries, their relationship within the pattern, and in particular their relative weight, remains essentially country specific. The economic argument is currently prevailing in some countries, in others the lead has been taken by the educational concerns, in others still, the educational responses are reflecting more of the existing political necessities. Only a few of the countries are developing policy approaches responding to most of the pressures at once.

17. These considerations provide the context within which a first taxonomy of policies can be established. The function of such taxonomy remains essentially descriptive: to chart the array of current educational responses to the NIT. Its objective is to identify the major forces at play in the countries, thus to forecast the most likely directions in which the educational situation might evolve. It is only in the light of these considerations that an attempt will subsequently be possible at evaluating the wisdom of the responses in educational terms.

18. What is proposed here is a taxonomy with a double entry. The first is by educational sector and leads to the definition of two broad categories of policies. One of them relates to the introduction of the NIT in all educational sectors, without distinction: the "comprehensive" approach. The other covers policies which put a higher priority on the manpower demands from the economy: the "vocational" approach. The second entry to the taxonomy differentiates policies according to the priorities given to specific needs of the educational sectors concerned. Theoretically, these could be classified under four broad labels: equipment, curriculum development, software development and teacher training. In practice only the first two, the "equipment" and the "curriculum" approaches, are mentioned hereafter, as no country policy can at the moment be said to give a higher priority to one or the other of the last two needs in isolation from the others.

19. It has to be underlined that the paragraphs hereafter give an overall picture of the situation in Member countries as it could be observed at the beginning of the 80s. Far from being static, the picture continues to change in most countries at a speed which makes it difficult to keep analysis up to date. Broadly speaking, the changes currently taking place would often suggest a different classification of the countries concerned, which seem to shift from one category to the other according to trends that are only just emerging. An example is the shift from "comprehensive" policies, on paper, to "vocational" ones in practice, observed in countries where the limited resources available for the implementation of the policies make it imperative to choose among stated priorities. Another example is the shift from "equipment" or "curriculum" approaches to more "comprehensive" ones observed in countries reaching further stages of development in this area. The examples given here have therefore to be considered only as indicative of possible policies and possible developments. No doubt the details of the situations will keep changing in the future in agreement with existing technologies, institutional possibilities and community pressures.

The "Comprehensive" Approach

20. The most telling examples of policies responding to most of the existing pressures are those developed in France and the United Kingdom. In France the government has set clear objectives for the introduction of the NIT in education. It is stated that:

i) Informatics should be part of general education for all;

ii) The NIT should be used to innovate all levels of education and to make teaching more effective;

iii) The NIT should be introduced to renew and update vocational and professional education.

21. The policy designed to serve the purposes reflects other preoccupations as well. The concern with the national electronic industry is reflected in the equipment policy: over FF 2 000 million have been allocated over a five year period (1980-85), to equip schools with nationally produced hardware. The target is eight microcomputers and a printer in each of the schools selected on the basis of geographical representation. The educational concerns are also well served in the French way to the technologies. Teacher training, educational experimentation as well as software production (the development of just the author language, Diane, represents an investment of FF 14 million over two years) have all been allocated a fair share of the resources.

22. If the highly centralised nature of the French educational system has certainly been a facilitator to implement such policies, the decentralised nature of the United Kingdom system does not seem to constitute a major impediment to implementing what is a rather similarly "comprehensive" policy approach.

23. In 1980, the Department of Education and Science for England, Wales and Northern Ireland launches the Microelectronics Education Programme, involving an annual expenditure of about £4 million. A year before the Scottish Ministry of Education launched the Scottish programme with roughly the same objectives and a quarter of the investments. Both projects serve typical educational concerns. They aim at:

i) Providing information and advice to all schools through a number of regional centres;

ii) Assisting the relevant educational bodies with intensive courses of teacher training;

iii) Developing curricular material, software (the MEP allocates about £60 000 per year to the regions to encourage software production) etc.;

iv) Encouraging the pooling and the distribution of software.

24. The industrial concerns are not covered by the policies developed by the educational authorities, but they are not for that reason absent from the scene. Together with the educational policies a national equipment policy has been developed by the United Kingdom Department of Industry offering financial assistance to schools purchasing hardware of national brands.

25. Canada offers other examples of "comprehensive" policy approach to the introduction of the NIT in education, at least in some of its provinces, such as Ontario or Prince Edward Island, where hardware, software, teacher training and curriculum development are all part of the same policy agenda.

26. The pressure from the world of the economy, with its double aspect of manpower and market demands are more predominant in other groups of countries.

The "Vocational" Approach

27. In a number of OECD Member countries the primary response of the educational system is to the demand for specialised manpower. The entry point for the NIT is, in these countries, the vocational sector. The policies developed have touched to a larger or lesser extent upon equipment strategies, curricular issues -- including software production -- and teacher training concerns. The speed at which the NIT penetrate from this to other educational sectors varies by country, but the overall pattern is similar. The NIT expand from the upper years to the lower ones, more often than not never reaching the primary level.

28. In Japan, the speed of diffusion is at its lowest. The vocational educational sectors has been the first, and so far the only one, equipped to needs. At present all the vocational schools are fully equipped with an average of six computers per school. The rest of the secondary schools will probably follow on the policy agenda. There are as yet no plans to introduce the NIT at the primary level in any co-ordinated way.

29. In 1983, the situation in Austria was similar. Most vocational schools were already equipped with microcomputers at a ratio of between two and twelve micros per school and a cost of over Sch 150 million over three years. Only 40 per cent of the other secondary schools were then expected to be equipped by 1985, with a more modestly planned expenditure of Sch 5-6 million per year. No plans existed for the primary education sector. By early 1984, the plans for all secondary schools have become more ambitious. The planned expenditure had been raised to Sch 20 million per year for a targetted equipment of all general secondary schools (years 5-12 or 9-12).

30. Finland and Luxemburg have adopted the same policy priorities. Finland will invest Mk 13-14 million a year (of which over 11 million as state aid) to bring its vocational schools up to their needs by 1988. The other part of the upper secondary level will follow, although at a slower pace. Nothing is foreseen for the comprehensive schools. Norway has given priority to its vocational education before involving the other branches of its upper secondary education. Note that the vocational institutions are the only ones in the country's educational sector to receive financial subsidies from the State to purchase equipment, although the 1984 White Paper on "Computer technology in the school" recommends that such subsidies be expanded to other educational sectors. Having started with vocational education, Luxemburg plans to equip all secondary schools by 1986 with an expenditure of LF 60 million. No plans are made for the primary level of this country either. In the Netherlands, the newly released White Paper from the Ministers of Education and Sciences, of Economical Affairs and of Agriculture and Fishing Affairs indicates similar priorities for their 1984-88 policies. About One fourth of the total budget will go to education, of which the largest part (65 per cent) is earmarked for the vocational sectors.

31. Most of the Mediterranean countries have taken the same approach, although their achievements remain in general more limited. In Italy, where the NIT have a large space in the vocational education sector, there is no

national policy planned nor co-ordinated experimentation going on elsewere in the educational system. Similar is the Greek and the Turkish situation, with even fewer initiatives taking place in the technical sector. Outside the technical sector, Purtugal is just starting experimenting with a few secondary schools, under the auspices of the University of Porto.

The "Equipment" Approach

32. A smaller number of Member countries are giving priority to investments in equipment, often adopting the top-to-bottom implementation pattern of the "vocational" approach. The "market" aspect of the educational response remains in these cases predominant, at least for the time being. Iceland had given priority to its secondary education to implement a policy of equipment of one or more microcomputers per school. Policy efforts in this country bear also on teacher training and curriculum development (computer studies and computer literacy) but little has been done as yet to develop the "software" counterpart of the policies. The situation is currently evolving towards a more "comprehensive" approach with the development by the Ministry of Education of the new curriculum in computer education for compulsory education and the relevant subsequent development software production by the National Center for Educational Material.

33. New Zealand is currently concentrating resources on its secondary level, which by June 1982, had 80 per cent of its schools equipped with microcomputers, purchased mostly through school funds. Some of the Australian states (e.g. Queensland) have also given prominence to equipment concerns with a two-tier policy on initial acquisition and subsequent on-going support and advice, provided, once more, that the purchases reflect central recommendations.

34. The concern with the national electronic industry is explicit in the recommendations, if not in the policies, put forward in yet other countries. In Australia, the 1982 Conference of Directors-General on "Computing and Information Processing in Australian Schools" stated that educational policies eventually developed in the country should support Australian high technology industry through the purchase of local hardware and software products. The Spanish educational authorities have also just launched the idea that educational specific hardware should be produced nationally. The Swedish development plan for secondary education -- a two year project in five communities -- hopes explicitly that the project will "give Swedish enterprises and industry a better chance of competing in the school computer market".

The "Curriculum" Approach

35. Fewer are the countries where educational concerns top alone the list of policy priorities. When it happens, the issue mostly adressed is curriculum development. Other educational subjects such as teacher training or software tend, in these cases, to remain peripheral to the core of policy and investment considerations.

36. The trend in such countries is to develop the curriculum on one or more educational lines or in one or more specific years within a given level.

Ongoing developments see some of the Canadian provinces adopting one or the other approach. Quebec plans to invest on curriculum development for the professional schools, Manitoba has plan for secondary education in general and Alberta tends to focus on the curriculum starting with Year 4. In Denmark, informatics is being introduced experimentally within the science curriculum, as an option in Grades 8 and 9 and a compulsory subject in Grades 5 and 7. National plans are being prepared, in these countries to introduce informatics in technical education.

37. In Sweden a major curricular -- and equipment -- effort has been launched in upper secondary education with a view to providing the same opportunities to students in the vocational and general lines. The investments were of SKr 4 million for the first year (1982). In Switzerland, nationwide experimentation is currently being implemented with informatics introduced in the last year of upper secondary education. In Spain, following a reform of compulsory education in 1981-83, informatics has been introduced in the 8th year of schooling

38. Among the curricular recommendations being formulated, one can mention the Irish and the Norwegian positions on the matter. The Norwegian Minister of Education has recently pledged that computer science should be available to all pupils. The Irish proposal is even more specific: informatics should enter their schools as computer literacy at junior cycle, computer studies at senior cycle, vocationally oriented courses at senior cycle and briefing courses for seniors not taking fuller courses

From Policy Approaches to Strategies of Implementation: The Role of Grass Root Developments

39. The previous analysis of policy approaches to the introduction of the NIT in education suggests already that the relative strategies of implementation can be expected to be at least as varied as the policies. Few countries have a national co-ordinated plan to offer in this field. At times the policy approaches are different because the countries have a different view on what it is desirable to concentrate resources on. At times this is because preference has been given to the path of least effort, when policies have linked the educational efforts to the strategic development of the national electronic industry, which has meant, incidentally, that education has been able to use resources from non-educational sources. Yet in other cases, the absence of national co-ordination is almost a juridical obligation. All federal countries fall naturally into this category. Decentralised educational systems are likely to have done the same, although exceptions exist.

40. Strategies of implementation cannot but be expected to amplify the variations. Because variations exist at the policy level, but also because equally large variations exist at the grass root level, where in almost every country the NIT have found their way into schools well before and irrespective of organised policy interventions.

41. Evaluating the wisdom of "official" policies and implementation strategies depends to an important extent on the possibility of assessing the nature and strength of these other forces, thus on the possibility to forecast whether the "official" and the "spontaneous" developments will reinforce or,

on the contrary will oppose one another. Only few elements of information are available at present for these kinds of considerations.

42. A first element suggests at least one aspect where official policies concord with grass root developments: the relative neglect of, or indifference towards, the primary education sector to the advantage of later educational years. In all OECD Member countries for which the information is available, the primary schools seem to see much less of the NIT than do the other school levels. With the exception of some Local Education Authorities in the United Kingdom, not one country reports the presence of the NIT in all primary schools. The current figures are more likely to be around a ratio of less than 5 per cent of schools equipped, with some federal countries such as the United States, Canada and Australia reporting equipment ratios of up to between 40 per cent and 50 per cent depending on the state/province. Note that for the secondary level figures over 70 per cent or 80 per cent are indeed very frequent as it appears from the information given in the Annex. While these official figures cumulate the effects of "official" and "spontaneous" developments, the fact that the pattern does not change when the schools are reported to have been the only purchasers (own funds or funds raised by teachers and parents) confirms our main conclusion of agreement between official and local agents on the targetting of interest and investments by educational level.

43. A second element of information brings some light on the possible existence of "field" forces which could or could not work in agreement with official initiatives. In many of the OECD Member countries more advanced in the introduction of the NIT in education the pattern of purchasing of hardware follows a similar pattern: more equipment money has come out of the normal equipment budgets of schools and local educational bodies than it has from special budgets made available centrally as part of the implementation of a "technological" official policy.

44. In Scotland, where the combination of the Scottish Microelectronics Education Programme and the Department of Industry equipment programme was intended to accelerate the introduction of the NIT in schools, the typical pattern of purchasing equipment was by late 1982: 10 per cent SEMP, 15 per cent DoI, 3 per cent other research projects, 72 per cent schools' own funds. In other countries one find the similar situation of more cases of equipment bought solely by schools own funds or funds from municipalities or school boards, than by a mixed funding formula with governmental participation of any kind.

45. If this can be taken in any way to indicate the existence of a local interest and expertise prior and possibly independent from larger scale educational projects, then any official strategy of implementation, needs to take this factor explicitely into account, as it might mean the existence of more variations than anticipated in, for instance, the hardware already present in the schools, the use it has been put in the curriculum or elsewere, the kind of expertise (or idiosyncrasies) developed by the staff involved and their readiness to adapt or adopt specifications which might run counter to their experience or expectations. It will then be left to the local decision-makers to modify the implementation plans to either capitalise upon the existing developments or, on the contrary to take steps to counteract them.

Chapter II

STRATEGIES OF IMPLEMENTATION: ORGANISATION, ASSESSMENT AND CONTROL

46. The previous chapter has highlighted the interests, pressures and concerns in the background of the policy approaches developed in the countries. To a large extent, the general lines of these policies have not been tied to the specificities of the information technologies addressed. They have rather reflected the overall pre-occupations of, and demands from, sectors in society such as the production or the labour market as well as the permanent concerns of educators to make schools meet traditional educational objectives. We have seen how the interplay of the different factors has resulted in somewhat different policy approaches, from the "comprehensive" or the "vocational" ones to those more specifically oriented towards the hardware market or education in general.

47. This chapter develops the analysis to the next level. It discusses how the policies themselves are being implemented in the countries, and how the concrete decisions and actions seem to be shaped by and, in their turn, shape the specificity of the technologies addressed and the uses defined for them. The chapter discusses how these technical and functional issues influence, and are influenced by, the implementation strategies adopted; how institutional responsibilities have been established on matters of equipment or software. The section is completed by a discussion on some of the implications for the curriculum, for teachers and for pupils.

Equipment Strategies

48. In most of the policy formulations in the field of the new information technologies and education the technologies themselves are identified rather narrowly and, to a large extent, imprecisely: more often than not the texts identify the hardware target simply as "computers". In that, the policies reproduce the selection operated over the recent years by the individual schools when responding spontaneously and autonomously (and perhaps erratically) to the newly developing markets of electronics. While more objective professional and technical criteria can of course be found at the basis of current policies formulations, it remains that most of the efforts of introducing the NIT in education aim at equipping schools almost exclusively with the new generations of computers: the micro and the mini computers.

49. Initiatives taken to introduce other technologies in education alongside or as substitutes for the previous ones, remain essentially

peripheral to the current efforts of government as well as from the initiative of local schools or educational authorities. Among these some are worth mentioning as, in a not too distant future, they might come to play a more important role in the functioning of education in the new "technological" world. Examples are the use of databanks as an educational tool starting in some Australian states, in both primary and secondary education. To the same category belongs the use of videotex optical fibres, videodisks, as experimented in France, Canada and the United Kingdom. One could also mention the link-ups to telematic networks at study in some of the Canadian provinces and Australian states, where the educational use of satellites is also under consideration.

50. But, as mentioned before, the technical term of "new information technologies" translates almost universally in educational policies as "micro and minicomputers". The singleminded governmental approach to these members of the NIT family goes beyond a simple question of narrow definition. It is the restricted target that is taken up in a number of countries under the responsability of the central educational authorities when developing strategies to equip the schools. Other new technologies such as telematic networks or old ones such as the audiovisual technologies are usually excluded from such considerations. This discrimination materialises in most countries either by direct purchase and allocation of specific hardware or by special purchasing grants given to schools and local education authorities (provided central purchasing recommendations are followed). The central involvement in the equipping of schools with microcomputers seems to be taking place in centralised as well as decentralised educational systems. For instance one finds a rather similar equipment policy approach in otherwise very dissimilar education systems such as in the United Kingdom where local educational autonomy is profoundly established, and in France, where the Paris-based Education Ministry has been ruling the national schools network without interruption since Napoleon times.

51. A first consequence of such equipment policies, centrally co-ordinated if not altogether directed, is to narrow the variety of microcomputers introduced in the schools to only a few of those available in the market. In addition to being narrow, such choice of microcomputers is usually also national; it may thus differ even considerably from country to country. We will discuss later on in this report what consequences this might entail for the future technological developments of educational concerns both within and across OECD Member countries.

52. A second consequence of central intromission in equipment strategies is the establishment of priorities between the two policy objectives of equity and efficiency. Although little is known as yet as to the specific impact of microcomputers on learning processes, it is obvious that such impact must depend, perhaps critically, on the time the learner spends with the machine. The number of micromputers per schools, or even better, per pupil in a school, is therefore an important parameter to consider when allocating equipment. The efficiency principle would require the allocation of resources on a progressive geographical basis, so that each successive school served has enough equipment to offer to its pupils. If an efficient equipment policy is certainly justified on educational grounds, its political legitimacy risks, in the current economic situation, to be unconvincing. This is perhaps the reason why most of the OECD Member countries having developed a policy on equipment have preferred equity to efficiency, whenever a conflict could

arise. The only explicit exception is France where the equipment policy is formally aimed at an initial target for each school and which has solved the equity puzzle by a careful selection of schools on the basis of geographical representativeness.

The Issue of Software

53. The contention that the purchase of computer hardware makes no sense unless accompanied by a parallel investment in software might sound as a platitude to anyone - and indeed it is. Yet few of the OECD countries have aknowledged the evidence in their policy formulations or their development plans. With the notable exceptions of France and the United Kingdom and, to a lesser extent, some of the Canadian provinces and the Australian states, the concern over the production and diffusion of the software needed to use the equipment purchased is all too often absent from the countries's policy considerations, although some signs exist that the situation could change in the future. As a matter of fact, the "White Papers" on technology and education released recently in Australia, the Netherlands, Norway and Sweden do recommend national policy developments of a more "comprehensive" nature. Until then local expertise and local financing will remain, in the majority of the countries, the main sources of initiatives in the field. At least in this first phase, the building up of the body of software needed to translate the word "equipment" into "learning activities" remains dependent upon this kind of ad hoc efforts.

54. Besides being, often, a peripheral subject of policy, the existing educational software can also be described as a good that is acutely scarce on the market. Whatever its origin (centrally or locally produced) educational software remains a rare commodity in the educational world. Besides, the little of it that enters the schools seems to be essentially endogenous to education, i.e. it is being produced, for better or worse, by teachers and/or by computer experts within ministries of education or local schools' education authorities. With few exceptions, such as in the United States, the current market of educational software for schools has been only marginally penetrated in the OECD countries by other traditional sources of educational materials such as the private producers or the universities.

55. Teachers seem to have produced, usually without central guidance, most of the software used in the schools of Denmark, Finland and Japan. Experts from the computing centres of ministries of education, working alone or in co-operation with schools' teachers, have authored most of the educational software in France (Institut National de Recherche Pedagogique), the United Kingdom (the central and regional structures set up within the Microelectronic Education Programme in England, Wales and Northern Ireland, and the Scottish Microelectronic Education Programme), Sweden (the expert teachers involved in the PRODIS project), most of the Australian states (the computing branch of the state's education department) and Belgium. The universities have so far played only a minor role in this field. France, Japan and Belgium, together with some of the U.S. states and the Netherlands seem to be the only reported cases so far.

56. The fact that most educational software is being produced within the educational system does not seem to guarantee, in any of the OECD countries, that it has a quality for education. Most educationalists do not hesitate to

qualify the quality of existing software with the euphemism "very varied". It would not be difficult to anticipate that in the absence, in most countries, of an official policy on software and with the uncontrolled multiplication of local piecemeal production the situation cannot but worsen in the years ahead. It is therefore important to identify what efforts are been made to find at least a preliminary solution to the problem.

57. The strategies developed in the countries to control the quality of educational software are usually of two kinds, which far from being exclusive, often co-exist and reinforce one another. The first family of strategies is of the "preventive" kind. It ensures quality in one of two ways: by issuing guidelines with specifications on programming and by controlling, as much as possible, the software's authorship. In the United Kingdom for instance, both in England and Wales and in Scotland, booklets have been issued with guidelines for teachers wishing to program. The Australian state of Victoria has also adopted this approach.

58. The second group of "preventive" strategies approaches the quality objective in, again, one of two ways. At times the authorship of quality is ensured by having the educational software produced within institutional bodies by especially hired -- and qualified -- personnel. In other cases, an authorship of quality is ensured at a more grass root level by making software production an important part of teacher training programmes. Examples of the first kind are more frequent. They include all the cases of "expert" authorship mentioned in the previous paragraphs, with the software produced mostly within institutional structures created by the country's educational authorities. The second approach -- through teacher training -- is so far rarer. The clearer example comes from France, with its carefully designed two-tier programme of training for schools' teaching staff.

59. The second family of strategies to control the quality of the software qualify as "remedial". They do not attempt to influence its production. Rather, they try to control or monitor the stream of software that actually diffuses into the schools. The form taken by approaches of this kind is to have qualified and official bodies issuing lists of approved material. This is the case of Canada, where in the province of British Columbia and Alberta groups of evaluators review courseware and produces a periodic list certified as of "good quality". This is also the case of the United Kingdom, where the body in charge of the implementation of the MEP, the Council for Education Technology, has taken a similar initiative. Since spring 1983, Finland has also adopted this approach, and reinforced it by a parallel initiative: the schools of this country are granted state aid when purchasing software issued from the official list from the National Board of Education.

60. Having a "quality label" marked on the product is certainly a useful guide to the buyers. In many case however, it is not sufficient to guarantee an optimal use of the resources available. To do that, the software needs not only to be good but also to "fit" the equipment or the curriculum already present in the school, i.e. it needs to be "transportable". The issue of "transportability" of the software is exceedingly complex. It can be defined in several ways, e.g. as transportability across equipment or computer languages, across disciplines or software producers. It is not the purpose of this report to consider the question in its many aspects -- this analysis is done elsewhere in the CERI project (CERI/NT/84.05). In this report we will confine the discussion to those (very limited) aspects of the issue that have

been most visibly addressed in the countries.

61. The strategies developed in the countries to insure transportability of the software have usually amounted to, first defining the problem in a very restricted way, and then developing solutions which are either proper to the simplified problem or a by-product of other strategies. The most common of such ad-hoc strategy has been to address only the issue of the language transportability. The usual form taken by the solution has been to adopt a common language either by prescription, as in France (LES), or de facto, as in Denmark and, more recently, Ireland, where the COMAL 80 language has rapidly become the most common programming language for educational software.

62. In addition to these specific approaches, software transportability is an obvious by-product of other implementation strategies. Any national equipment policy, by restricting the variety of hardware introduced in the schools ensures software transportability at least at this level. Similarly, solutions to the problem of software "quality" contain elements ensuring other kinds of transportability. The formulation of guidelines for programming or the control of authorship introduce an element of similarity and homogeneity in the software produced which, if not solving the problem altogether does certainly alleviate it.

63. The development of strategies to produce software, to control its quality and to ensure its transportability are the first elements in the chain bringing the products from the producers into the schools. To close the circuit, one needs to develop the final link of making the products known and accessible to the users. Yet information and distribution networks are, in most OECD countries, in an extremely primitive state. With the exception of those few countries, such as France and the United Kingdom, where a co-ordinated effort is being made to introduce the new information technologies in education, and where the software produced is made available by the same agencies that control its production and quality, the way in which schools related to the available software is at best hazardous. As examples of the variety of situations one could mention how software moves in Japan (by diffusion and exchange between two large teacher associations in industrial and commercial schools), in New Zealand (within and between a number of users groups and computer education society), in Western Australia and in Tasmania (within a communication and distribution network set up by the Education Department) or in Ireland (by care of the Computer Education Society).

64. The discussion of software issues concludes the (rapid) analysis of that part of the introduction of the NIT in education which lies, as it were, between the ministery of education and the school's gate. To continue our journey from the policy makers into the classrooms, we need, at this stage to consider the ways whereby the issues considered above -- strategies of policy implementation concerning equipment and software -- translate in questions more pertinent to the daily practice of education. This will be done by considering, successively, the issues of the curriculum, the teachers and, finally, the pupils.

The Curriculum

65. The translation of equipment and software strategies in curricular issues can be best represented by a branching tree, with an important -- and

clear -- bifurcation at the bottom and a profusion of secondary branches all the way up. The first main differentiation occurs by level of education, between the primary and the successive school years. If the equipment of the primary schools is less affluent than at the secondary level, its use is, on the other hand, simpler and clearer. Across the OECD countries, the primary curriculum sees the computers used mainly for drill and practice in basic skills and, accessorily for remedial education. The secondary curriculum, on the other hand, involves the computer in very different ways, with specifications depending in an often unclear fashion on the specific level of schooling considered, the discipline, the school and the country.

66. In general, the computer has entered the primary schools essentially as part of "computer assisted instruction" for, as said above, drill and practice and remedial education. Few are the countries where the uses have been more ambitious. Examples of this kind come from some of the Australian states where elementary school children are taught, in some schools, a few elements of computer science (usually programming through LOGO). Notions of computer science are also given at this level in the United Kingdom and in Denmark, where experiments in "datalaere" are run in years 5 and 6. Next to computer science, some primary schools have also introduced "computer literacy", mostly but not exclusively as an integrated subject within the mathematics, social sciences and civic curriculum. The actual provisions in this case comprise formulae ranging from a full 30-hour course in years 4, 5 and 6 in the Canadian province of Alberta, to a more modest integration in other curricular subjects, as is more frequently the case.

67. The situation in secondary education is rather different. The kinds of provisions introduced within the schools curriculum are so varied that it is difficult to establish even a superficial taxonomy. Under the label of "computer assisted instruction" the computer, no longer confined to the sciences, has penetrated virtually all curricular areas, although at speeds which vary greatly across countries, schools and levels of education. The curricular status and content of computer science and computer literacy (or appreciation) are equally disparate.

68. One of the first (and unexpected) elements of inconsistency in this area is the absence, in some contries, of clear-cut boundaries between what are commonly called "computer science" and "computer literacy", which are usually roughly defined as covering technical subjects on computers and considerations on their social implications, respectively. In Finland, for instance, since the 1982 reform, the two fields have been simply merged into one. In England and Wales, the computer science curriculum has "historically" covered subjects such as the uses of computers and their effects on society. Conversely the "computer literacy" curriculum in Scotland or the United States often includes elements of programming. In Norway, computer appreciation is available as an integral part of the computer science syllabus, and also (in some schools) as an independent, and compulsory, course.

69. Equally disparate is the actual organisation of the courses available in the countries, both across and within the national borders. The overall situation can best be described by the laconic response of the United States education authorities to the CERI questionnaire: the provisions available vary widely in content and length. One can indeed find that to teach computer sciences in Canadian secondary schools takes anywhere between 50 and 100 hours in a year, depending on the school and the province. In Belgium it takes

between 294 and 336 hours a year for the specialist students and "only" 84-168 hours for the other vocational education students.

70. The variations found for courses in "computer literacy" (when a differentiation of labels, if not of content, exists) are of the same order of magnitude. Across the Australian states the curricular time taken up by this subject varies from a lowest five hours a year, in Tasmania, to a highest 126 hours a year in the Capital Territory. In New Zealand the variation is less important ranging between 12 and 30 hours a year for the unit of study offered in Form 4.

71. The only (modest) trend observed in this area is that the length of the courses offered seems to increase with the age of the learner. In Western Australia computer science is offered for 1.5 hours a week at Grades 9, 10 and 11, and for more than double that time at Grade 12. In Luxemburg, the time allocation goes from 72 hours a year at Grade 11 to 164 hours a year at Grades 12 and 13. In New Zealand, the corresponding figures are of 80 hours a year in Form 7 to 160 hours a year in Form 6, with this last opportunity offered, it must be said, in few schools only.

72. Such multiplication and differentiation of the provisions created in the countries in the 1980s has devitalised the traditional ammunitions brought by the supporters of computer science as a separate or an integrated subject by to the heated debate of the 1970s. With the exception of a very few countries such as Sweden or Denmark which have taken an explicit policy stand on the question in favour of integration, other national situations are mixed at best. In Finland computer science is taught as a separate discipline in 90 per cent of the schools, but also as an integral part of the Mathematics curriculum. The situation in Spain is similar with the option in Grade 8 integrated and that in Grade 12 separate. In New Zealand the shorter course given in Form 7 is part of the mathematics curriculum, while the longer provision offered at Form 6 constitutes a separate subject. In the Australian state of Queensland, computer literacy appears also in the two curricular forms.

73. In view of the above, it certainly does not come as a surprise to see that little consensus exists within and across the countries as to whether "computers", in whatever curricular form they come, should be an object of formal examination. Computer science is a subject for the "abitur" only in a restricted number of the German Länder. It is also an option for the 'O' level in mathematics in Ireland. In Scotland computer science is being piloted in 17 schools at the same examination level. In the other countries the situation is varied. At times the "computers" are simply absent from the exams' programme. At other times "computers" are the object of examination. In general education lines, they usually appear as a subject integrated in other established disciplines. In the vocational education certification system, they are dealt with mostly as an independent examination subject.

74. The above curricular considerations draw a background against which the following analysis of the situation of the teachers called to teach the new subjects and to use the new educational tools and to produce the new software acquires a much fuller meaning.

The Teachers

75. The CERI project on the introduction of the new information technologies has addressed the question of teachers in great detail in a separate and specific study (CERI/NT/84.08). This activity aims at discussing the changing roles and functions, if any, of the teaching force in an educational world equipped with the new technologies. It is not the objective, nor the ambition of the present report, to address such questions with any degree of depth. More limitedly, we report hereafter the highlights of the countries' replies to that part of the CERI questionnaire dealing with the subject matter. This is the main reason why, in what follows, the complexity is reduced to the consideration of just one of the questions: the issue of teacher training.

76. The strategies of implementation of training policies for teachers seemed, at the eve of 1984, to be very similar to those discussed for the software and the curriculum: unclear (an array of provisions with no clear-cut taxonomy in terms of objectives, content, duration and level of education addressed is reported in Australia, Canada and England and Wales), unsatisfactory (Japan) or non existent (only nine out of the 24 OECD Member countries have reported having any training provisions for teachers in the field of the new information technologies). As in the previous two cases, the lack of adequate attention and resources at the policy level is more than superficially related to the current situation.

77. A first remark to make in this respect is that full fledged policies specific to teacher training have been formulated only in two countries: Sweden and France, where special funds have been set aside for the task. The new technologies have been introduced in the Swedish teacher training provisions within the general reform of the field in 1982, which has involved an initial investment of SKr 3 million by the government. The provisions made available are mainly in-service and are tied to the curriculum. Teachers from the compulsory cycle receive a three week course on computer appreciation. Teachers from upper secondary schools are trained for longer. Their courses last for at least five weeks and involve more advanced computer-related subjects such as computer utilisation and programming.

78. The initiatives taken by the French government are an important part of its ambitious plan to introduce the new technologies in education comprehensively. These provisions are the only ones so far in the OECD world that differentiate between various teaching functions with respect to the NIT, such as between the software producers and the users, and between the trainers and the trainees, with the first receiving a full year training course (in universities) and the latter only a lighter 12 days (in local settings).

79. As for the other countries, the existing provisions can be outlined only approximatively, at this stage. One could remark, for instance, that less initial than in-service provisions exist, with only half the countries with any provisions at all reporting having both. Among the existing initial provisions a slight trend can also be observed towards finding provisions for primary school teachers more often -- or less seldom -- than for teachers at the secondary level. Usually these provisions are introduced as part and parcel of the regular courses for teachers certification.

80. A number of different considerations can be formulated for in-service

training. First, and almost surprisingly, the differences in equipment observed in all Member countries between primary and secondary schools does not seem to translate into corresponding differences in teacher training provisions. It is as if more equipment on the premises of secondary schools had little incentive value for the creation of correspondingly more important provisions for teachers.

81. The lack of differentiation between the two levels of teacher training is also to be found in the provisions themselves, which do not differ markedly as to their typical duration, content, authority in charge or qualification of the trainers. With the exception of Sweden, already mentioned, and of Belgium, where the length of the training courses in the Dutch speaking area varies by school level (from a 24-hour course for primary teachers to five to ten days for teachers from state schools and ten to 14 days for the further education sector), most of the other countries seem to have defined both responsibilities and expertise similarly across educational levels, without any visible rationale. The providers of teacher training provisions are usually the educational authorities of the country or the state.

82. From the same educational authorities are usually issued the trainers, often specialist staff from the ministries or the schools themselves. Belgium and France seem to be among the few cases where the trainers come from academia, usually because of their expertise in informatics and irrespective of their experience as educators. The Northern Territory in Australia and the Canadian province of Ontario are among the very few instances reported where the trainers come from the private sectors, from consultancy agencies or the computer manufacturers themselves.

83. In numbers, the situation described in the previous paragraphs means that only a low percentage of the countries' teaching force has so far received any formal training to make good use of the equipment newly introduced into the schools. In France, where the investments are largest, 630 teachers have so far followed the "heavy" training and the 15 000 others the "light" one, with similar figures expected for the year 1983/84. In Scotland, where a special effort in teacher training is also being made 2 000 primary school teachers have had some formal training while the number of secondary school teachers remain unknown. In Sweden, the carefully designed programmes have served 6 000 teachers in two years. In other countries, such as England and Wales, Canada or some of the Australian states the ratio of the teaching force trained does not exceed few percentage points.

84. Yet the demand from the teachers is sizeable, their attendance to the courses, usually voluntary, shows unmistakably that they are interested to learn -- primary and secondary education teachers alike usually apply for training courses in numbers far exceeding the places available. The behaviour of the teachers is mirrored by the attitudes of the teachers' unions often more open and positive towards the introduction of computers in the schools than they were 15 years ago towards audiovisual material.

85. The need for more and better training provisions for teachers, both initial and in-service, remain an important question for policy considerations, as urgent and vital as software production and diffusion and curriculum development. It is hoped that the small numbers of teachers thus trained indicate only the beginning of a growing process, which will perhaps accelerate with time. Some countries have started ambitious projects in this

respect. France hopes to add a further 20 000 teachers a year to the cohort already trained. Sweden would like to have all its teachers of mathematics, social studies and vocationally oriented subjects trained by 1986. The United Kingdom (England and Wales) is aiming at having at least two teachers per school trained. These initiatives are promising in quantitative terms, it remains, of course, to be seen whether the quality will follow.

The Pupils

86. At the receiving end, where the pupils stand, most of the implementation strategies discussed previously have only an indirect -- although essential -- bearing. The fact that the hardware is of national or foreign manufacture is not of much interest for the learner, provided the performance is correct. The fact that the software has been written by teachers or by experts of informatics, that it has been bought by the education authorities or given free by the manufacturers, is equally non-relevant for the learning process, provided, of course, that its educational quality meets the standards. The particular curricular status granted to computer science -- a separate discipline or an integrated subject -- does not perhaps matter provided the pupil in the course of his or her educational career has been given access to that body of computer-related knowledge needed to function in society and, in particular, in the labour market.

87. What matters most to the young is the effective access to the new educational goods and the presence, at his or her side, of a competent teacher. This is the angle under which the investment in human and material resources made at the policy and implementation level, becomes visible to the school's beneficiaries, their families and the community at large. These are the parameters along which the evaluation will be made (perhaps erroneously) by the general public. The extent to which this "visibility" is being achieved in the OCED countries is illustrated by some of the information included in the countries' replies to the questionnaire.

88. A first point which emerged from the replies is that the access to the NIT is not granted evenly across the educational system. The compounded effect of the various strategies whereby the NIT are being introduced in education is that important cleavages exist in the school population between age groups and between pupils of different educational lines. Additionally, the data made available to the Secretariat show that at times a gap exists of a more geographical nature -- in some countries, such as the United States and Western Australia, the schools that could be defined as "better off" in traditional educational and socio-economic terms are also better off in the NIT.

89. The age cleavage is the most commonly found in Member countries. It separates the primary from the secondary education pupils. It is built mainly on differences in equipment and software. At times these differences have emerged spontaneously in all those countries where, as we have seen before, the purchase of equipment and the production of software rest essentially on local resources and motivation. One could mention, in this respect the example of the United States where a recent NCES survey has estimated the number of students with easy access to or actually using computer terminal: 2 000 primary pupils per terminal as compared with 370 in the secondary level (1).

90. At other times, the differences are the result of explicit pecking orders established by policy between educational levels. This is the case in countries implementing the "top to bottom" or the "vocational" approach in equipment strategies. Yet in other cases, the situation is the outcome of specific decisions being taken at the policy level excluding primary education pupils on the grounds of inadequate cognitive development -- the younger pupils are said to lack the mature cognitive skills required to master, say, the concepts of computer science. This is the case, notably, in countries such as Sweden, where the now completed DIS project has been instrumental to the non introduction of computer-related subjects (actually, programming) in the primary curriculum. We have seen in the section on the curriculum how this point of view is far from being shared among all OECD countries.

91. The differences by educational line are to be found less frequently in the countries than those by level. When they exist, they separate the pupils in general education from those in the other educational pathways. The difference is at its deepest in those countries where the "vocational" approach has dominated or dominates current policy formulations, such as in Austria, the Mediterranean countries and Japan.

92. To say that some groups of, if not all, pupils have access to the NIT does not necessarily mean, however, that these pupils are served up to their needs. We have seen in the previous sections how many of the schools in the countries are equipped with microcomputers. We have also seen, how these number translate in ratios of schools equipped with respect to the total number of schools in the country. We can now indicate how these figures translate in average equipment per school. At the primary level, the typical school in the Australian state of Queensland has no more than 2.3 microcomputers. The figure for the same state goes up to 3.1 in the secondary level. In Japan, in January 1983, the average number of microcomputers per school does not exceed 1.4 in the primary level, 2.2 in the lower secondary and 4.1 in the upper secondary institutions. A typical school in Scotland has only one or two micros, while in England and Wales it has five to six. In the United States, in January 1983, less than 10 per cent of primary and about 40 per cent of secondary schools had five or more micros. In Switzerland "equipped" secondary schoools have an average of 5.5 microcomputers, with an average of about one working post every 13 pupils, in the last year of upper secondary pupils. It is to be argued whether the official obectives of eight (France) or 16 (Luxemburg) microcomputers per school would bring the figures to the level advocated by some German teachers, that is one workstation every two to three pupils (2). Note that in some of the vocational schools, such as the Austrian commercial schools, this quantitative objective has already been reached.

93. To deduce from the above figures a "hit parade" of countries established on the basis of the quality of learning ensured by the equipment (and eventually the software) available to the pupils would be tempting. At this moment in time, however it would also be at best premature. In fact, for all we know of the impact of the NIT on learning processes, each of these numbers can be equally good or bad for the learner. On the basis of further information on this point (CERI/NT/84.10), we can only terminate this section on pupils as recipient of the NIT-based education, on a note of caution. In the end, alongside their economic value for education, the educational potential of the NIT will have to be measured in terms of learning benefits. The analysis of the effect on pupils remain central to any policy

considerations. In the end it is in these terms that the wisdom of any specific formulation of goals and strategies in equipment, software, curriculum or teacher training will have to be assessed.

Chapter III

EMERGING TRENDS AND CONCLUSIONS

94. The introduction of the new information technologies in education is well under way in most of the OECD Member countries. The speed of development varies across the national borders, the policy approaches and the implementation strategies are also different from one country to the other, but the process has started and shows little signs of slowing down or to reverse motion. This is undoubtedly a first main conclusion to draw from the information analysed in the previous two chapters.

95. The same analysis, however, shows that far from witnessing a finished product, the situation we currently observe in many countries is still only an embryo of what the "new" educational world could be. In biblical terms, one could almost say that if a time tag had to be put somewhere along the holy week introducing the new information technology in education, it would be hard to place the current situation much further ahead than Monday or Tuesday.

96. There is no doubt that the efforts have been important in a number of countries, that the financing has been sizeable, the motivation of all those concerned important (and the coverage by the media even more so), yet the results achieved so far in any educational system as a whole seem to remain positively limited. Looking at the vast amount of problems waiting for solution at all the levels from policy formulations to classroom practices it is difficult to avoid the feeling that if much has indeed been done, much more is still needed to complete the task.

97. In this perspective, the considerations to be developed in this last section of the report cannot be only short-term, but they need to cover as much as possible at least a medium- if not a long- time range. This we will do by trying to identify, in specific examples from the countries, those aspects of the changes under way which seem most likely to remain important in the years ahead, to discuss those problems the solution to which might be determinant in shaping tomorrow's education.

98. The task is certainly arduous. The situation keeps developing at a very fast pace. The technologies themselves are progressing and transforming. Important non educational forces (economic, industrial, political and institutional) are still active in steering educational decisions virtually everywhere. This results in a high degree of uncertainty likely to surround educational courses of action for many years still. Any set of considerations on the future which we might develop here cannot be but

tentative and cautious. The task needs nonetheless to be performed, because educational decisions need to be taken without delays and because the present remains the time where the future is actively built. It is with the full awareness of both the limits and the necessity that the considerations hereafter are put forward.

99. Few would dispute that in considering the introduction of the new technologies of information in education, the core of the problem is to bring within education, within the group of decision-makers, of administrators and practitioners, a body of knowledge and expertise which does not belong to it, but originates and develops mostly outside. Micro and minicomputers are part of the latest developments in electronics, their programming is primarily performed within the world of informatics, their most advanced applications are to be found in the economy, in both the production and the service sector. To translate the understanding therein in educational applications is not easy nor is it straightforward. To effectively combine technological with pedagogical know-how, one needs first to complete an indispensable preliminary step: the construction, within education, of a large enough body of experience and knowledge on which further decisions could be taken soundly.

100. Although not always in a consistent nor a comprehensive way, this is what is being done in a number of countries. Their initiatives seem to show that, at least in the current initial phase, the main objectives to be aimed at can be phrased as the achievement of critical mass.

101. The analysis of the previous chapters has already shown which are the critical fronts involved in the introduction of the NIT in education, where most of the efforts and investments have been concentrated and most of the problems encountered: the equipment of schools with hardware, the development of educationally sound software (with the sister issue of curriculum development) and the training of the teaching staff. The achievement of a critical mass of experience and understanding on all the fronts involves the consideration and the solution of a number of problems, general and specific.

a) The Policy Level

102. At the general level a number of dilemmas can be identified. A first one is for policy. The different nature of the forces and investments at the origin of the observed developments, makes it likely that the three fronts will continue to develop as they have up until now: at essentially different speeds, independently from one another but likely to be mutually influential. Yet, in policy approaches, none of them can be neglected to the advantage of the others as each one plays an essential role in bringing about the desired changes.

103. While acknowledging the problem, in their experts' recommendations if not in their official policy formulations, none of the Member countries seems to have found a satisfactory solution to the riddle. In times of scarce resources, a few have decided to spread them and tackle the three fronts at once in an integrated approach (e.g. France, the United Kingdom and some Canadian provinces), others have chosen to concentrate their efforts on one front at a time, in a step-by-step fashion and according to means, usually starting with the equipment (e.g. Finland, Dutch speaking Belgium, Japan), in a fewer cases with the curriculum (e.g. Denmark, Spain, Sweden and

Luxemburg). Yet other countries, have adopted a more modest beginning by attacking only one or the other of the "critical fronts" in a fragmented way and neglecting, for the time being, the others (e.g. curriculum in Switzerland).

104. Given the interrelation between the various fronts, the first approach -- the building up of critical mass in a slower but more comprehensive way -- could be more promising in achieving global understanding. The second approach is certainly better adapted to the differential speeds of evolution by sector but slower at including in the knowledge accumulated those elements related to the important interplay underneath. The issue of adequate resources remain in both cases critical in determining the wisdom of adopting one approach instead of the other.

b) The Institutional Level

105. A second dilemma is for institutions. The dicussion of strategies of implementation has shown the complexity of the operation in terms of the bodies involved, at the centre as well as at the periphery. It has also shown the existence of sometimes strong local expertise, motivation and sources of financing and control, with which more formal initiatives have to contend. In this context, whatever the policy strategy adopted to achieve critical mass, the success of its implementation depends rather critically on the establishment of an adequate degree of co-ordination between the various partners involved. Concretely, this means the creation of institutional bodies or the setting up of institutional arrangements which are centralised enough to ensure maximum speed of communication within the network yet decentralised enough to allow each of the component parts evolve primarily under their own steam.

106. Few of the countries are so far ahead in the introduction of the NIT in education to have had to find an overall solution to the dilemma, although examples exist by sector. France and the United Kingdom are the countries most advanced in this respect. Their solution is to have established a unitary structure, depending on the central education authorities, which overlook and co-ordinate the whole process while leaving enough space to local initiatives. The "Agence à l'Informatique" and the "Council for Education Technology" perform basically the same task with respect to the educational system and have essentially the same prerogatives with respect to more decentralised agencies. They represent the converging point of institutional developments in otherwise very different educational systems, a highly centralised and a highly decentralized one. At their origin we find the need to design an institutional strategy dictated more by the nature of the implant than by that of the receiving tissue.

107. The establishment of a unitary structure to co-ordinate and control developments, thus to facilitate and accelerate the achievement of critical mass, can be found in a number of other OECD countries. More often than not this structure takes the form of a special body defined within or dependent from the education authorities. This is the case of, for instance, Sweden, Belgium and some of the provinces in Canada. Next to this, some forms of larger co-operation have been introduced such as the consortium linking the three Australian states of Tasmania, Western Australia and South Australia. In general, like in the United Kingdom and France, these institutional

structures depend from the education authorities. Unlike these two examples, however, their field of relevance is usually more limited. The front more often adressed by these structures is, once again, equipment, followed closely by curriculum development, sometimes by software and, only erratically by teacher training. In all case the success of the enterprise, remains critically linked to the readiness of the parties concerned to trascend established institutional rigidities and prerogatives and exchange and cooperate across administrative borders.

c) The Level of Research

108. A third dilemma faced in the achievement of critical mass is for research. All through this chapter we have spoken of "critical mass", yet we know very little as to what the concept really amounts to, either globally or specifically. What "critical mass" means in terms of equipment for a country, a region or a school? What is the "critical" computer-related curriculum time, below which no effect can be expected in the learner? How does the concept translate in terms of size of the park of software? How many hours of courseware we need to produce to achieve the desired educational objectives, by level of schooling or by discipline? How many teachers do we need to train, and for what?

109. Of course, if one had the time and the resources to conduct all the research and experimentation needed to answer these questions, there would be no dilemma. One would just wait to gather enough information and be in a position to define the targets properly. Only then one would turn the matter to the policy makers and the administrators to design the optimal strategies. But that is not real life. In real life the time constraints are usually as ponderous as the resources are light. Yet decisions have to be taken without delays, on whatever information is available, however limited it might be.

110. Few of the OECD Member countries have taken the decisions to delay the large scale introduction of the NIT in education until research and experimentation are completed, at least sectorially. The few examples that exist chiefly concern the curriculum. Among these one could mention Sweden, where a systematic plan of research has been carried out since the turn of the 80s to decide on possible subject-related computer utilisation (the projects DIS and PRODIS) and on the possibilities of computer assisted learning. Another example comes from Switzerland, where experimentation is also going on in terms of curriculum innovations in the last year of upper secondary education. Research programmes also exist in a few more countries to assess the forms under which the computer can enter the primary schools.

111. All these examples come from the world of schools, and are all submitted to the scrutiny of the education authorities. It is doubtful that these kind of initiatives would, alone, allow the solution of the dilemma in any short term perspective. To go faster one would need to tap at expertise built over the years on the same subjects but in different territories such as the research community and the private sector. The CERI project is endeavouring to gather information on this body of existing knowledge. When that will be available we will be able to discuss more concretely how the information can actually be brought to bear with the preoccupations of policy makers, administrators and practitioners.

112. So far in this chapter we have dealt with the problems such as they can be defined and solved by the community of the people in charge, within the ministries, the schools and the specialised agencies. To conclude this section on the achievement of "critical mass" one has to mention one further contribution which could come from a group of people often ignored in these kinds of educational decision-making and problem-solving: the young people themselves.

113. Besides being cheaper and smaller, the latest generations of the NIT seem to possess another additional quality: they are attuned to the young. Again, the media never fail to give prominence to the sometimes spectacular achievements of the younger child or the barely adolescent. Yet, besides the smoke screen of the broadcasts the fact remains that the young achieve surprisingly much as a producer in the field. Not many educational authorities seem to have acknowledged the evidence, thus wasting the possibility of tapping this kind of expertise.

114. Among the few who have, one could mention Denmark, where the now internationally known computer language COMAL 80 was originally developed by a group of students. Yet in other countries the creativity and knowledge of the young is encouraged to come to the fore through national competitions. This is the case of Germany with the "young researcher" competition where informatics as well as mathematics is one of the six subject areas, and with the youth competition organised by the "Gesellschaft fur Informatics" in computer programming. This is also the case of Ireland with the 'Memory Ireland Computer Competition", open to all schools, which provides opportunities for all pupils to present individual and group projects on computers and their applications. The young obviously represent an additional avenue to achieving "critical mass" soonest.

Concluding Remarks

115. This report has dealt with a number of issues ranging from the development of policy approaches to the establishment of strategies of implementation aiming at introducing the new information technologies in education. The analysis of the information forwarded to the Secretariat by the relevant agencies in the OECD Member countries shows the important similarities existing across countries as to the interests, motivations and pressures at the origin of the processes under consideration. The analysis also indicates the differences in some of the policy priorities set out in the countries as well as in the resources made available or the investments foreseen. It also outlines, however sketchily, the extent to which such similarities and differences have been influencial in shaping the specific courses of action undertaken in the countries to achieve the state objectives.

116. Among the elements that emerge more clearly from this first study one could emphasize once again what seem to be the characteristics of the process under consideration as well as the main problems identified so far. The introduction of the new information technologies in education is a very long term process of which, even in the countries most advanced in the field, we are witnessing what amounts at best to a very first phase. The difficulties this might cause at the policy (and planning) level are further compounded by a number of specific problems linked to the nature of the process itself -- research and development datas are as yet scarce -- thus on the

uncertainties still surrounding the definition of detailed pedagogical and organisational objectives.

117. This report, while acknowledging the complexity and the extention of the problems, has also shown how solutions are gradually being developed in the countries, albeit slowly and at considerable cost. Yet, this is not altogether surprising. The examples considered in this analysis show how unrealistic it would be to expect that it will be easier, less costly and less wasteful to introduce the NIT in education than it has been to reform, change or innovate it on other scores.

118. In its century-old life and besides its pedagogical expertise, the educational system has had the time to grow strong as an institution, with its established habits and its corporate interests. Around the educational system an equally strong network of pressures and influences has developed breeding on political, economical and cultural forces. The willingness to innovate is present everywhere but the resistance to change is also ubiquitous. To open a passage through the system to introduce the NIT is equally tolling in human and material resources as it is to introduce any other change which might affect the pillars of the system and the surrounding network.

119. As in other recent instances of strong pressures to change, such as the one of "opening the school to the world of work" brought about by the problem of youth unemployment, the introduction of the NIT in education might be considered as threatening one of the central pillars on which the system rests: the exclusive expertise over educational matters and their delivery. As in the other example, the threat comes from the fact that the knowledge needed to bring the change about belongs primarily to the surrounding agents. Yet, in this case as well as in others, without loosening the barriers, without pooling human and material resources, without co-operating across agencies public and private, as well as across national borders the risk is sizeable that resources will be used up for little results. In particular, the introduction of the NIT in education will take longer and will cost more. In the end the doubt remains if it will be carried out at all.

NOTES

1. Andrew A. Zucker, Support of educational technology by the U.S. Department of Education: 1971-1980, Office of Planning and Budget, U.S. Department of Education, Washington D.C., June 1981

2. Peter Gorny, New Information Technologies in Education in the Federal Republic of Germany, European Journal of Education, Vol.17, No.4, 1982

Or. Engl/Fr

Annex

AN OVERVIEW OF THE INTRODUCTION OF THE NIT IN MEMBER COUNTRIES

PRIMARY AND SECONDARY EDUCATION

This Annex presents an overview of the situation in OECD Member countries. In line with the fast changes taking place in the area of education and the new information technologies, the information hereafter has been collected on an on-going basis. The first round of data was gathered in early 1983, through a questionnaire sent by CERI to the Member countries in Summer 1982. As a good deal of the data became obsolete within six months of their gathering, a first updating of the information was carried out in October 1983, in view of presenting a first version of this document (CERI/NT/83.11) to the Advisory Group to the project in December 1983. Since then, the life time of the new set of data has proved to be no longer than that of the previous set. A second updating has therefore been carried out in early 1984 in view of the presentation of this document to the Conference on Education and the New Information Technologies of 9th-12th July, 1984.

The information hereafter has therefore to be taken as representative of the situation in Member countries in early 1984, with the understanding that the near future might see it change in most countries, at no slower a pace than in the recent past.

The following Member countries are included in CERI/NT/84.02 Addendum: Belgium, Finland, Greece, Japan, Norway, Portugal, Spain, Switzerland and Turkey.

AUSTRALIA

Current Situation

In Australia developments in educational uses of computing have started in the senior levels of secondary education and gradually diffused into lower secondary and later to primary education. Different states are at various stages of development but all are showing this type of development.

The involvement of the Commonwealth Schools Commission in computing is seen as a major development. In early 1983, the Commission recommended that $A 125 million should be allocated for computer education over the next five years. In July 1983, the Government decided for a more modest initial investment: $A 18 million only for the triennum 1984-86. Initially the programme will concentrate on secondary schools. For the period beyond 1984, the Commission is asked to prepare options on possible future policy directions for this programme, including extensions to primary schools.

Primary Education

Equipment - Park	The situation varies widely from state to state. Some states have a policy about the use of computers in primary schools (e.g. Western Australia). In all states the number of machines found in primary schools is increasing rapidly. In Tasmania 80 per cent of all primary schools have one or more computers.
Equipment - Financing	Funding for education is primarily a state concern but schools make their own decisions using their own budgets. Some states offer help to schools purchasing "approved" equipment. For example Western Australia provides up to 50 per cent of the purchase price of a computer system.
Target Group	Those schools having computer equipment make it accessible to all students. Most states have experimental activities aimed at special schools or students with specific learning difficulties.
Curriculum - Computer Science	No state offers a formal course in computer science for primary students.
Curriculum - Computer Appreciation	All states provide courses in computer appreciation for primary students. Most states have policies directed to "universal computer literacy".

Teacher Training	There is great diversity across the country. Some states have formal programs in computing as part of their educational training while others rely on in-service training. This is seen as one of the key areas for attention as part of the Schools Commission programme. All states provide "on-the-job" training for teachers interested in computing applications for the classroom.
Access to Data Banks and to Telematic Networks	The Australian packet switching network is only just available so few education computer users have made use of the system. Some states provide access to international networks such as Dialogue and Source but few students would experience this type of computer use.

Secondary Education

Equipment - Park	Most secondary schools in Australia have access to computer equipment. All states report that more than 60 per cent of their secondary schools have some computing capacity. In Tasmania all secondary schools have computer facilities.
Equipment - Financing	Like funding for primary schools funding computer equipment for secondary schools is primarily a state concern but schools make their own decisions using their own budgets. Some states offer help to schools purchasing "approved" equipment. For example Western Australia provides up to 50 per cent of the purchase price of a computer system.
Curriculum - Computer Science	This varies widely across the country. In Victoria and Tasmania computing is available as a university entrance subject. Other states offer courses at senior secondary levels and some offer no formal courses in computer science. e.g. South Australia.
Curriculum - Computer Appreciation	All states have courses in computer appreciation at secondary level. These courses are generally seen as transient in nature and reflect the "newness" of computers in our society.
Software Production	Most states rely on commercial software producers for the bulk of their software needs.

	Some states have centres which develop software for schools but this can only account for a small fraction of the total software needed. Three states are experimenting for the commercial sale of their software.
Software - Diffusion	All states have set up some type of structure for the distribution of software.
Teacher Training	Like initial training, the situation varies from state to state. All secondary teacher training institutions now offer some type of computing unit in their courses. Much of the training is seen to require in-service courses for practising teachers. The Commonwealth initiative will play an important role in this area.

Trends for the Future

Australia is large in area but with a small population. This places high priorities on effective communication links. AUSTPAK, the public packet switching network, will probably play an important role in improving software transfer and access to data bases.

The first Australian satellite is to be launched in 1985 and this is also expected to assist with data communication. There is a proposal to link together some or all of the states for the purpose of software and other information exchange.

With the general "shake out" of the microcomputer manufacturing market there is a trend towards more standard equipment in schools. This is supported by the Schools Commission recommendations. Already three states, Tasmania, South Australia and Western Australia have decided to share their software resources. This trend should continue.

In the primary area the numbers of computers will increase as the cost decreases and more software becomes available. This will create problems in teacher training and software support.

AUSTRIA

Background Information

The educational system is characterised by a high degree of centralisation. Major curricular changes require a two-thirds majority in parliament. Changes in the content of a subject can be decreed by the Minister of Education after submitting the draft for comment to the nine provincial school boards (by law) and to a considerable number of interest groups (by custom). Pilot projects are possible at any time, but in strictly limited numbers.

New curricula may be formulated with the contribution of educational staff at all levels as well as repesentatives of employers' and employees' associations. The two basic issues of relevance and attainability are decided on the basis of experience and common sense rather than research. The universities are only involved in the case of subjects prerequisite for university admission. Pupils are not involved except through informal feedback.

Current Situation

The kind of educational system as in Austria is difficult to penetrate by initiatives at the grassroots level or of a piecemeal nature, which constitute a typical first phase of penetration of the NIT in countries' educational systems. The primary level is virtually untouched, while there is a planned partial introduction in the general secondary schools by 1985.

The only educational level fully penetrated by the NIT is the one directly linked to the labour market's needs: the vocational schools, which are attended by 68 per cent of all full-time pupils (37 per cent with university access, 31 per cent without university access).

Upper Secondary Education

Equipment Park	In seven of the nine provinces, approx. 35-40 per cent of schools have been equipped with a configuration of four workplaces, each equipped with a microcomputer of 64 K-bytes capacity as a minimum, including display screens, twin floppy-disc drives and one printer each.
Equipment - Financing	Mostly by federal authorities, the remainder by owners of private schools. Over Sch 20 million have been spent over a period of two years.
Target Group	Pupils aged from 16-18 (Grades 9-12).
Curriculum - Computer Science	Courses are offered as an optional subject: "Electronic data processing".

Curriculum - Computer Appreciation	Information on computer applications and social consequences is given in several subjects.
Software - Production	Software is generally of commercial origin. Some is developed by teachers and/or pupils.
Software - Transferability	Ensured by uniformity of equipment (in particular CP/M operating system) and textbooks.
Teacher Training	Initial training in data processing is an option for students of mathematics education. Many further training courses are open to all teachers but mostly attended by those of mathematics. A large proportion of the trainers are teachers self-taught in micro-electronics.

Vocational Education

Equipment - Park	Commercial schools: At each of the more than 100 commercial schools with university access, a single-function classroom (two at the larger schools) is being used, comprising ten workplaces, each equipped with a microcomputer of 64 K-bytes capacity, including display screens and twin floppy-disc drives. Each group of five microcomputers is wired to a selector box and hence to a printer. As classes never exceed a size of 18 pupils -- larger classes being split -- one workplace is available for every two pupils. In Austrian commercial schools with university access a total of 1 300 microcomputers and 260 printers are being used, and the computing rooms are equipped according to a common performance sheet. Furthermore some schools have minicomputers, used for computing proper, whereas the micros with special software are used in accounting and word-processing. Industrial schools: There are more than 40 industrial schools with university access, using mainly multi-place systems with six to ten terminals and an average core size of 256-512 K-bytes. In one industrial school in Vienna computer specialists are educated for the business and industrial sectors. Both teachers and students of the secondary and postsecondary sectors use the mainframe computer of the Ministry.

Equipment - Financing	Mostly by federal Authorities; remainder by owners of private schools. Over Sch 150 million have been spent over a period of three years.
Target Group	Pupils aged from fourteen up.
Curriculum - Computer Appreciation	Information on computer applications and social consequences is given in several subjects.
Software - Subject Areas	Science, technology, commerce.
Software - Production	Software for commercial schools is developed by computer firms, teachers and school administrators. In industrial schools, packages are bought from commercial firms. To some extent software is also developed by teachers.
Software - Diffusion	Diffusion is ensured, initially, by the Ministry of Education.
Software - Financing	Ministry of Education.
Software - Quality Control	Groups of expert teachers commissioned by the Ministry of Education.
Software - Transferability	Ensured by uniformity of equipment and textbooks.
Teacher training	Provision for training in computers is available at both the initial and in-service levels. Attendance is compulsory at the initial, voluntary at the in-service courses. Instruction includes programming, accounting, word and data processing, measurements, communication and control. A large proportion of the trainers are teachers self-taught in micro-electronics.
Access to Data Banks and to Telematic Networks	One pilot project: a commercial school with access to the Postal Authority's Data Bank.

Trends for the Future

Primary Education

Training of primary teachers is in the concrete planning stage.

Secondary Education

By 1985, all general secondary schools (years 5-12 or 9-12) are expected to be equipped with a planned annual expenditure of A Sch 20 million. By the school year 1984/85 it will be possible to choose electronic data processing as an option for the leaving age examination at the general secondary schools.

A working group of the Ministry is about to prepare the general introduction of the subject "Electronic Data Processing" in the upper secondary schools. Two hours per week will probably be compulsory for two years and optional thereafter. Thus the student has some control over the extent of his training in this subject.

In the area of teacher training for electronic data processing, planning strategies of the Ministry over the last few years have resulted in an average two or three teachers trained for teaching this subject at every general secondary school.

Vocational Education

Computer Science courses are being introduced in hotel and agricultural schools; and, gradually, in industrial schools.

Austria's apprenticeship education and training covers 225 trades. Apprentices spend 20 per cent of their time in part-time vocational schools. Since these are province-financed, all equipment is purchased by provincial authorities, who also implement the national syllabi and determine to what extent microcomputers are being used in part-time vocational schools. From 1984 electronic data processing will be explicitly introduced to the commercial and related trades via new syllabi, test projects having being successfully carried out over the past few years.

CANADA

Current Situation

The new information technologies are present to a considerable extent in the Canadian schools, at both the primary and the secondary level, although great variations exist across the provinces. Next to the more familiar use of the NIT as a teaching aid and as a component of the curriculum, Canada has initiated a number of educational experiments, mostly but not exclusively at the secondary level, involving new and innovative uses of the new technologies, such as satellite linkages, telecoms and television networks. Despite the sometimes considerable developments in equipment and educational design, Canada has still to solve the problems of formulating a coherent policy approach at both the federal and the provincial level, and of establishing effective co-operation and exchange across the provinces.

Primary Education

Equipment - Park

The percentage of schools equipped with computers ranges greatly across provinces. In December 1983, 30 per cent of Quebec and 45 per cent of Alberta primary schools were equipped. The province of Ontario has focussed its equipment policy on the production of an educational microcomputer called the ICON that has been developed in accordance with Ministry specifications having their bases in the nature of the learner and the learning processes as well as the up-to-date innovative capacities of electronic hardware. Any other machines developed in accordance with these specifications and that have been evaluated as such would be approved for use in schools. Schools usually have audiovisual equipment although there are great variations (from 7 per cent to 80 per cent) by provinces.

Equipment - Financing

School Boards are the principal source of financing for computer equipment.

Some schools have used funds raised by the schools themselves, by teachers, pupils and parents.

In one case (Quebec) the funds have come through the Ministry of Education research grants.

In another case (Alberta), the provincial government has assisted schools purchasing hardware and software. The province of Ontario is developing policies whereby, for an initial period, school boards will bear only 25 per cent of the cost of recommended hardware.

	Audio-visual material is usually purchased jointly by the ministries of education and the local school boards.
Target Group	All pupils and the tail-ends -- the gifted (especially Quebec) and the underachievers -- depending on the province.
Curriculum - Computer Science	In one province only (British Columbia). Generally speaking, provinces feel that, while it may be possible to teach computer science as a separate subject at the elementary level, it is not desirable to do so. Instruction would thus be limited to achieving computer literacy applicable to a variety of subject areas.
Curriculum - Computer Appreciation	Some provinces, but not all, have introduced, or are considering introducing, computer literacy courses in their primary schools. Since September 1983, Alberta has been piloting a 30-hour unit in computer literacy at Grades 4, 5, and 6. In other provinces computer awareness courses are integrated into other subjects such as social studies.
Software - Subject Areas	Reading, writing and mathematics. Development of formal thinking (in five provinces). Instruction of graphic drawing and electronic games (in British Columbia, Ontario and Quebec). LOGO is researched at Queen's University. It is introduced at a varying degree in the schools of three provinces (Ontario, Nova Scotia and Alberta). Computers are also used to support existing courses such as Art, Second-language Instruction, Mathematics, Science and Computer Science.
Teacher Training	Some provision exists at both the initial and the in-service training level. Attendance is usually voluntary. The percentage of teachers trained varies by province. Initial as well as in-service training is a joint effort of departments of education, universities/teachers' colleges and computer

manufacturers. In British Columbia, for instance, computer suppliers train district staff who in turn train local school staff in the use of the computer. In Ontario, the province, by way of TV Ontario, offers teachers the opportunity to participate in the educational television network's Academy on Computers in Education, which constitutes an integrated learning system centering on a 12-part TV series entitled "Bits and Bytes". The Academy is marketed to all sections of the Ontario educational community with the support of the Ontario Teachers Federation.

A variation of the same series, called "Octopuce" is broadcast in Quebec since October 1983. 12 000 have enrolled so far in the related correspondence course. A number of them are teachers. Additionally, a December 1983 survey has indicated that 25 per cent of the 25 000 teachers have followed a "light" training of between 10 and 45 hours. A further group of eleven teachers has undergone a "heavy" training of 180 hours over a period of five months. Another 1 500 teachers have enrolled in university courses.

Access to Data Banks and to Telematic Networks

Four provinces report the presence of interactive videotex units in elementary schools. They are however limited in number and of experimental use.

In Manitoba and Alberta, elementary schools have access to specialised data banks.

Telematic networks are established in a school division in Manitoba (a network of micro-message and telephone lines), in two Nova Scotia school districts (using educational channels of local cable stations to schedule, as required, programmes selected from an available bank of tapes).

Nova Scotia is also examining the possible use of four hours per day of satellite time made available by a commercial TV station to distribute programmes to schools which could be recorded for later use.

Secondary Education

Equipment - Park

Across the provinces, between 7 per cent and 90 per cent of schools have computer equipment.

	Most schools have audiovisual equipment. The main types of utilisation identified are non-interactive information retrieval and the play back of pre-recorded programmes.
Equipment - Financing	Computer equipment purchased with the combined effort of the departments of education and local school boards. Video facilities financed by provincial departments of education and school boards through the allocation of funds by local school divisions/district boards.
Curriculum - Computer Science	General computer science courses are offered in the Business and Technology area. All provinces do not appear to distinguish between generalist and specialising students of computer sciences. Students spend from two to 15 hours per week on computer studies. Total hours of instruction vary from 50 in Saskatchewan to over 100 hours in Nova Scotia. Basic courses can start as early as Grade 9.
Curriculum - Computer Appreciation	The subject is integrated into computer science/literacy programmes or into other disciplines such as social studies. It often includes computer history, sociological implications and the development of the students' critical understanding of computerisation.
Software - Subject Areas	Mostly Mathematics, Sciences, Social Studies and Language Arts although all disciplines are represented especially in the field covered by computers as an educational aid.
Software - Production	The emphasis on the creation of courseware directly by a ministry of education and/or connected institutions varies substantially across provinces. Active provinces in this area are Alberta (software produced by the teachers of the Correspondence School), Ontario and to some extent, British Columbia. In other provinces commercial software is used. Quebec, for instance, reports that about a hundred commercial products are also available for classroom use. Some provinces report limited activity on the part of universities and teacher training institutions in the creation of courseware.

Software - Diffusion	Courseware is of fairly easy access, provided the necessary funds and information are available.
Software - Quality Control	The quality of currently available courseware is apparently inadequate. The general provincial consensus would characterise available courseware as poor or spotty with only one province rating materials as fair to excellent. The Quebec Department of Education has developed a series of instruments to be used in verifying the quality of courseware. British Columbia reports that 100 evaluators review courseware as requested and produce a periodic list of recommended materials. Alberta has established a clearinghouse function where courseware is reviewed. It publishes lists of recommended, prescribed and supplementary materials. Two more provinces are developing an approved list of software and courseware materials, and two more are considering the possibility.
Software - Transferability	By standardising Apple format for all approved courseware, the Alberta Department of Education is, to date, alone in having taken a policy position in this area.
Teacher Training	Some provision exists at both the initial and the in-service training level. Attendance is usually voluntary. The percentage of teachers trained varies by province. Between 20 and 30 per cent of teachers undergo initial training in Nova Scotia. In Quebec, 4 000 secondary school teachers (13 per cent of the total teaching force) have received a "light" training of between ten and 15 hours. Eleven more have received the "hand" version of 180 hours. About 3 000 more follow university courses on the subject on a voluntary and independent basis.
Access to Data Banks and to Telematic Networks	Alberta has seven terminals for interactive videotex located in schools in various communities across the province. Ontario has a Telidon project underway involving 100 teletex and videotex terminals

located in schools, youth employment centres and libraries. The Student Guidance will be on the system and will involve from 50 000 to 100 000 Telidon pages.

Six Quebec and three Manitoba secondary schools have terminals.

As for telematic networks, in Ontario telephone lines link schools to bases of the Ministry of Education for statistical and financial information, student reporting and scheduling. The Ministry is also promoting and monitoring the Alternate Delivery System which uses a combination of correspondence course materials, television, videotex and other media for course delivery in areas where a teacher's expertise is unavailable.

A development plan is formulated by the Quebec Department of Education, while New Brunswick reports that the general area is under study.

Trends for the Future

Primary Education

While the introduction of computers as an educational aid remains largely a local or regional initiative, four provinces (Prince Edward Island, Quebec, Ontario and Alberta) are developing a comprehensive approach in this area. The model retained in Prince Edward Island is a Computer Advisory Committee established within the Department of Education to advise on applications, utilisation standards and in-service training. A global policy on pedagogical applications of computers is being developed in Quebec. In Ontario the recently completed "Planning Report on Educational Computers in the 80s" will, if approved by the Ministry of Education, set the blueprint for broad provincial initiatives. Additional measures include the issuing of functional specifications for the design of an educational microcomputer for use in Ontario, the provision of funds for producing lessonware, and the development for curricular guidelines for the intermediate and senior classes.

Secondary Education

Same developments as for primary schools. In addition, Alberta anticipates the development of a five-year plan and New Brunswick is developing a comprehensive plan in co-operation with all provincial school boards.

As opposed to comprehensive plans for the introduction/development of computer science programs in schools, most provinces point to more basic measures such as the development of a Grade 10 computer literacy course in Alberta, or the revision of the curriculum by the Manitoba Department of Education. A plan is also developed for Quebec schools to add computer studies to professional studies programmes.

A Toronto-based technical school is experimenting with the use of videodisc in conjunction with the Ontario Institute for Studies in Education. Similar experimentation is also going on in Alberta.

The province of Ontario is implementing a software development programme, covering many areas of the curriculum. Approximately C$5.4 million will be allocated in 1984-85 with up to C$10 million by 1986.

DENMARK

Background Information

1970	Minister of Education sets up a Committee (Johnsen Committee) on the teaching of informatics.
1972	A report is delivered recommending that informatics be introduced at *all* stages of education and training. The Social Democratic Government proposes the subject *optional* in lower secondary education (Grades 8-10).
1973	The Government changes.
1975	The new School Act for primary and lower secondary does not even mention informatics. It puts a halt to the experiments which had been steadily growing in the 1970-75 period.
1980	The Ministry of Education issues a new circular for upper secondary which stops the experimental teaching of informatics as an independent subject and urges that instruction, while remaining experimental, should start integrating informatics in science subjects (Jensen, 1982). Six schools start experimental education along the new guidelines.
1982	Informatics is *experimentally* introduced in *two* local authorities, as a *compulsory* subject in Grades 5-7 and as an *option* in Grades 8-9. A new detailed curriculum for the integrated computer science in upper secondary is issued by the Ministry of Education.
1983	Roughly a third of the upper secondary schools apply for the integrated computer science. Due to financial reasons only 22 actually start. Informatics is experimentally introduced in second chance education.
1984	A curriculum stating that integrated computer science be a compulsory part of upper secondary education is being prepared. The School Act for primary and lower secondary is being changed so informatics becomes an option in Grades 8-10 and a compulsory part of the curriculum, the local authorities to decide whether integrated in existing subjects or as a separate subject.

Current Situation

After a decade of, first, development and then decline of scattered experimentation in the field of informatics in education, Danish education is slowly evolving towards a more coherent approach to policy and development.

Compulsory Education

Equipment - Park	About 5 per cent of schools had microcomputer equipment in November 1981. The figure is expected to rise beyond 15 per cent in 1984.

	Some schools have video equipment.
Equipment - Financing	Funds come from the municipalities without subsidies from the state.
Curriculum - Computer Science	Experiments in "datalaere" as an independent discipline have been carried out in 1982/83 and 1983/84 in Grades 5 and 6. In the municipality of Odense, the most advanced in the introduction of the NIT in education, informatics is offered as an optional subject from the eighth to tenth forms.
Curriculum - Computer Appreciation	The social consequences of more widespread utilisation of computers in society are treated in the social science course, which is compulsory in Grades 8, 9 and 10.
Software - Subject Areas	Computers as a teaching aid have been introduced first and foremost in special education for remedial courses in the basic skills. A moderate amount of software exists in physics, geography and biology (simulation of experiments), and in home economics (to establish data bases for nutritional values of food items and dishes).
Software - Production	Most of the software used in Danish schools has been produced by teachers, with only a minor part provided by commercial suppliers. Additionally, the Dental College for Education and Training, together with the Jutland Telephone Company, has developed a special system, the "Datamaskinformidlet undervisningssystem" (DUS), which is now expected to allow teachers with no knowledge of computer programming to write their own software.
Software - Transferability	The adoption *de facto* of a common computer language, COMAL 80, which was originally written as an extension of BASIC by a group of students (Jensen, 1982), ensures transferability.
Access to Data Banks and to Telematic Networks	There is no use of telecommunication for educational purposes and none is envisaged.

Secondary Education

Equipment - Park

About 99 per cent of general secondary schools had computer equipment in 1983, averaging around six workstations per school. Computers are to be found in all vocational schools (Jensen, 1982).

Curriculum - Computer Science

A core of 20-80 hours of instruction is compulsory for all students in vocational technical schools, while an additional set of 60-80 hours is optional or compulsory depending on the specific vocational area (Jensen, 1982). A core of 100-200 hours of instruction is compulsory for all students in vocational commercial schools.

Trends for the Future

General Trend

At present, while controlled experimentation has started again in a number of schools, there is still no national development plan to introduce the NIT in education. However, Mr. Bertel Haarder, Minister of Education in the Schlüter Government, has appointed a committee which should assist in the establishment of new priorities for the teaching of informatics. A separate committee will advise the Minister on the introduction of informatics in technical education.

FRANCE

Background Information

1970 An International Conference organised by the OECD launches the French debate on the introduction of the NIT in education.

1970 The "Mission à l'Informatique" is created within the Ministry of Education. The declared objective is to make visible the potential impact of the new field of knowledge on all school subjects. It is proposed to achieve this aim by:

-- Training 500 teachers from all disciplines through a one-year course in informatics;

-- Producing software in a new language (LSE, Langage Symbolique d'Enseignement) especially developed for the programme;

-- Allocating microcomputers in schools evenly spread geographically.

1972 The "opération 58 lycées" is launched by the Ministry of Education equipping 58 schools with mini-computers each with eight terminals and a printer. The presence of specially trained teachers was a main criteria of selection for the school.

1980 As part of a micro-informatic plan under which the Ministry of Industry was allocated funds of FF 2 000 million over a period of five years, the "operation 10 000 micros" is launched, aiming at equipping each of a number of secondary schools with eight micromputers and a printer by end 1985. There was no direct link between this programme, of the Ministry of Industry and the previous "58 lycées" one. In particular, this new programme was started without waiting for the assessment of the previous one to be completed.

In parallel with this wide-scale introductin of micros into lycées, a number of experiments were launched in a few "collèges" and ordinary schools.

1981 After a change in government, the industrial component of the plan, originally strong and almost exclusive, is enlarged by an active concern with teacher training.

1982 A specialised project is launched aiming at the development of a new author language, Diane, which should open the access to software design to authors without specialised knowledge in programming. The Diane project was expected to represent an investment of FF 14 million by 1984.

1983 Before completion of the "10 000 micros" project, a new and more ambitious one is launched aiming at achieving, by 1988, an equipment park of 100 000 microcomputers in schools, a bulk of as many teachers trained in informatics and the corresponding production of software.

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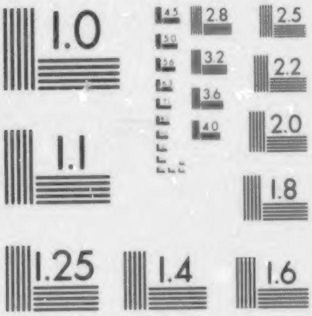
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

At the end of the 1982/83 academic year 5 423 microcomputers were to be found in state schools, distributed unevenly, 80 per cent and 20 per cent respectively, between upper secondary (general and vocational) and lower secondary establishments and virtually absent from the primary educational sector. (*Le Monde de l'Education*, 5/4/83).

Current Situation

The main policy efforts are on equipment (with nationally produced hardware), teacher training, educational experimentation and software production with priority given to upper secondary education.

The three general objectives are:

-- To introduce notions of *informatics* at all the levels of basic schooling;

-- To foster the use of *informatics* as a teaching instrument, especially with the underachievers;

-- To adapt and develop vocational and technical education so as to reflect the growing importance of *informatics* in the various sectors of the economy.

Primary Education

It is possible to give an accurate figure for the total number of units installed in primary schools because of the variety of agencies financing such acquisitions. Such financing may be entirely local (local authorities) or result from contracts between the State (Ministry of Education) and the Conseils Généraux (Councils in each Département).

Thus with the help of joint State/Conseils Généraux financing, about 2 000 TO 7 microcomputers (French manufacture) will have been installed in primary schools by the end of the 1983/84 academic year.

Curriculum - Computer Science

Neither "education" nor "initiation" accurately describes the Ministry's plan for primary schools: it was decided to describe the computer science activities that will be available to these schoolchildren as an "EVEIL" ("introduction": "introduction to computers and technology").

Software

In the strict sense of the term, *educational software* is "software used to instruct a particular subject matter". The Ministry, however, does not intend to use it for this purpose in primary schools. Relatively few schools are involved and on an experimental basis. Broadly speaking, all the software for use in schools is produced, distributed and evaluated within the joint framework of the Centre National de Documentation Pédagogique

(CNDP). As for the areas in which software is used in schools, none has been ruled out since none has been systematically investigated from the standpoint of the "Introduction" that is planned.

Teacher Training	Teachers are given training in the Teacher Training Colleges by instructors that have been given a year's training in one of the Centres de Formation Approfondie à l'Informatique (Centres for Advanced Computer Sciences Training).

Lower Secondary Education

Equipment - Park	-- The 84 schools selected nationwide on an experimental basis and equippod with six MICRAL microcomputers and one printer will be receiving a seventh microcomputer; -- The schools in 16 French Départements have been equipped with a total of 2 300 TO 7 nano-machines in sets of 6, 8 or 12.
Equipment - Financing	-- Independently-supplied equipment: extremely varied and difficult to evaluate; -- The Ministry of Education (and the Ministry of Industry and Research) for the first 48 locations; -- Departmental and regional authorities; -- In some instances, local authorities and own funds.
Curriculum - Computer Science	Nil.
Curriculum - Computer Appreciation	Several isolated experiments, in most cases incorporated in the school project.
Software - Subject Areas	-- Primarily in the context of computer-assisted instruction; -- Also for self-tuition and clubs.
Software - Production	-- Stock of existing material in the library of the Centre National de Documentation Pédagogique (CNDP);

	-- Specially produced by school teachers.
Software - Diffusion	-- General distribution: the CNDP; -- Limited distribution: the colleges' computer sciences unit for "non-official" products.
Software Quality Control	-- By CNDP procurement agents under the authority of the Directorate for Colleges; -- By the teachers themselves (reports on software used).
Teacher Training	-- Training of users (50-100 hours); -- Training of group supervisors (250 hours); -- Training of instructors (750 hours); -- Self-training.
Access to Databanks and to Telematic Networks	Still in its infancy; however several experiments under way, e.g. ARGUS in Rennes, TELEMEDIATHEQUE in Bordeaux.

Upper Secondary Education

Equipment - Park	1 000 schools equipped with configurations of 4 - 8 semi-professional type microcomputers plus a printer. By 1987 all schools will be equipped with one or more instructional configurations consisting of equipment designed for semi-professional or general use.
Equipment - Financing	The Directorate for Lycées, local and regional authorities, schools' own funds.
Curriculum - Computer Science	Computers are used as a teaching aid in all subjects (CAI). They are also used as an aid for thought and action (statistics, data gathering and processing). In the general education curriculum, computer science is being offered as an option on an experimental basis. In vocational curricula, computer science is included in training courses for industry (BTS Informatique industrielle) and the services sector (BEP Agent des Services Administratifs et Informatiques, Bac H, BTS Services Informatiques). In 1984, total expenditure on modernising computer equipment (chiefly as

regards production processes and office automation) and training technical education staff, funded in conjunction with other Ministries and "établissements public régionaux", will amount to FF 65 million in the schools sector (lycées of vocational education, technical lycées, advanced technical departments).

Software

The Directorate for Lycées has put out a request for the production of educational software. Their educational content and format are worked out by teams of teachers. Their technical execution and distribution are handled by the CNDP. Production at a national level is supplemented by software produced locally on the initiative of teachers.

Teacher Training

In-service teacher training in computers is organised on a two-tier basis. A "heavy" programme (one year with full-time attendance) is offered by 20 universities to teachers who will then train the others through "lighter" courses (four sessions of three days each). In 1981/82 and 1982/83, 630 teachers received the "heavy" and 15 200 the "light" training. The "heavy" training aims, among other things, at enabling teachers to become subsequently members of teams for training other teachers in the use of microcomputers, creating educational software and giving certain courses in information technology. The "light" training only trains them to use the software available. A further 500 teachers have undergone the "heavy" training and 20 000 the "light" one in 1983/84. A self-service elementary course in informatics will also be developed shortly to allow a larger number of teachers as well as the general public to acquire a basic understanding of the new discipline.

Trends for the future

The programme of action that has been launched is designed to achieve by stages the full-scale integration of information technology within the education system:

1985	Achievement of target for the installation of computer equipment in institutions of higher education.
1986	Achievement of target for courses in the electronics field (an additional 3 600 graduates per year).

1988	Achievement of target for the equipping of schools: installation of a total of 100 000 microcomputers complete with educational software.

By the end of the first plan for continuing education, 100 000 teachers will have been trained in computer-assisted instruction, with all teachers who so desire being given some basic instruction.

This entire programme is beng carried out by the Ministry of Education in conjunction with the other ministerial departments concerned and, in particular, the Ministry of Industry and Research.

GERMANY

Background Information

At the beginning of the 1970s, the Laender of the Federal Republic of Germany begun introducing computer science in secondary level teaching.

The Federal Minister of Education and Science (BMBW) and the Laender have, since 1971, provided support for 54 pilot-projects, allocating a total of more than DM 52 million (the Federal Government and the Laender contributed 50 per cent each). For the period 1984-1986 BMBW will provide another DM 3.44 million for the promotion of current pilot-projects in computer science and the Laender will provide the same amount.

These pilot projects and in particular the uniform inter-Laender examination requirements in the Abitur have had a strong and beneficial influence on the organisation of computer science teaching.

All the same, the forms and opportunities of computer science teaching vary quite considerably from one land to another. This is due among other things to school organisation, but above all to Laender-specific prerequisites for teacher training and the equipment of schools.

Current Situation

With its Government report on "Information Technology", the Federal Government will shortly submit to the German Bundestag a general concept for promoting the development of micro-electronics as well as information and communication technologies.

According to the Federal Government's opinion -- which is shared by the Laender -- such a concept will also include integration of technological developments in the education system with regards to contents and didactics.

After the introduction of computer science as a subject in secondary level II by all Laender of the Federal Republic, in particular in the grammar school, the central issue now is how to ensure a broad-based education in computer science for all pupil of secondary level I.

Some of the Laender have already carried out far-reaching practical measures or largely drawn up their own plans.

Within the framework of the promotion of pilot projects within the Bund-Länder-Commission for Educational Planning and Research Promotion (BLK) this issue will be given attention by establishing a new priority area for pilot projects.

There is agreement between the Federal and Laender governments on the fact that the new information technologies are a subject in its own right as well as a tool for improving and clarifying teaching in other subjects.

The contents of teaching to be developed are as follows:

-- Provision of basic qualifications for tackling problems by using information technologies and handling of pertinent devices (computer literacy);

-- Acquisition of knowledge of the practical applications of the new technologies in everyday life as well as in working life;

-- Formation of an independent opinion on the possibilities and limits of these technologies.

Secondary Education

Equipment - Park

In two Laender 100 percent of the schools with upper secondary education are equipped with computers. In the other Laender, this percentage varies from one Land to another between 30 and 80 per cent.

Intermediate schools (lower secondary education) are equipped with computers only to a small extent. In one Land only the percentage is as high as 60 per cent. Second level compulsory schools (lower secondary education) are equipped with computers only in a few cases.

Equipment - Financing

The school sponsors are responsible for funding school equipment (as a rule the local authorities; in the case of private schools the private sponsors)

Target group

All students in the types of schools mentioned above.

Curriculum - Computer Science

In all Laender (in Schleswig-Holstein only as a trial run), computer science is offered at secondary level grammar schools (upper secondary education) as a basic course and -- in the Saarland -- also as a special achievement course. In most of the Laender computer science can be chosen as a third or fourth Abitur examination subject.

At the same time, computer science can also be taught in the form of optional instruction (e.g. in working groups). In some Laender, computer science classes are offered for Grades 9 and 10 of intermediate schools and grammar schools (lower secondary education), either in the optional sector or by integrating it in other subjects.

Computer science curricula cover the elaboration and realisation of algorithmic problem solutions, know-how and computer science applications, and take account of the most recent state of the art. At present, computer science classes are attended by about 10 per cent to 15 per cent of all students of the respective age group.

In addition, the field of computer science is dealt with in classes covering the subjects of mathematics, science and technology.

Curriculum - Computer Appreciation

The opportunity and risks of the information society are dealt with in social sciences and other related subjects. For this special topic there are only very few co-ordinated curricula concepts and specially trained teachers.

Software - Subject Areas

Courseware is available mainly for subjects as mathematics, computer science, natural science and economics.

Software - Production

Most of the courseware has been written by teachers. Some courseware has been developed under the pilot projects mentioned above. In addition there are several scientific institutions which have developed courseware, above all for natural science. Commercially produced courseware is available to a very small extent only.

Software - Diffusion

In some Laender there are public institutions which compile and document courseware and make it available to schools and also advise schools on the production of courseware. Additionally there are private insitutions, in which teachers, university lecturers and others have joined forces in order to compile, document and exchange courseware.

Software - Quality Control

To the extent that software is disseminated via the Laender institutes mentioned above, the latter are responsible also for quality control. The same is true to a certain extent of the scientific institutions mentioned and the associations of teachers and lecturers.

Teacher Training

In some Laender, grammar school teachers can -- mostly by passing an additional examination -- acquire the qualification for teaching computer science. In other Laender, the teacher training examination in mathematics may include computer science as an examination subject.

In all Laender the emphasis of teacher training in computer science is and will be for some time on in-service training and continuing education.

Vocational Education

At the beginning of 1980, the Federal Ministers for Economic Affairs and the Federal Minister for Education and Science directed the Federal Institute for Vocational Training to take account of the development of microelectronics in his work on the re-organisation of occupations which require formal training. A major issue here is the question of which microelectronics contents should be taught in vocational training. The activities are conducted with the participation of industrial experts. Their participation ensures that technical developments forseeable in individual industries are taken into account by initial vocational training. This also applies to the drafting of the outline curricula by the Permanent Conference of the Education Ministers of the Laender for instruction at vocational schools, the aim being to co-ordinate them with training directives.

The re-organisation of commercial occupations, which has almost been completed, was greatly influenced by the development of information technologies. For a total of 12 commercial occupations requiring formal training, between 1977 and 1981, a uniform concept for the acquisition of knowledge and skills in data processing was included in the training directives as well as in the outline curricula for vocational schools. For these occupations, data processing is an examination subject in the final examination together with the fields of "organisation" and "accounting".

The number of pilot experiments in the field of "Information Technology and Vocational Education" is small to date. As announced in the Federal Government's 1983 vocational education report, the Federal Minister of Education and Science started a number of pilot experiments on "New Technologies in Vocational Education" in January 1984. With a funding volume of DM 20-25 million, about 20-25 projects can be carried out in firms, interfirm associations, inter-firm training facilities etc. At the same time, experiments at vocational schools are to receive promotion in the framework of pilot experiment promotion by the BLK.

The results will help to develop transferable and practical solutions to allow young people to acquire qualifications enabling them to master the demands of the new information technologies in their occupational life. At the same time, the results help to further develop (modernize) vocational education and to revise or amend existing training directives.

ICELAND

Background Information

1965 Computer studies are started in higher education.

1971 Computer studies are introduced in upper secondary schools (Grades 12 and 13).

1978 Computer studies are introduced in secondary schools (Grades 10-13), especially within the commercial educational sectors.

1980 Vocational schools begin offering computer courses to most of their students whereas such training had begun earlier in electricity and electronic courses, and has been later extended in graphic arts programmes.

1982 The Ministry of Education establishes a task group to evaluate the situation and make recommendations for further planning. The group has compiled a report including a variety of proposals.

Current Situation

The Ministry of Education is preparing a curriculum in computer education for compulsory schools, secondary schools and university colleges of education, to be completed in the autumn 1984. In addition, the Ministry has asked for bids to be submitted for the purchase of microcomputer systems for schools. Decisions on which equipment to buy will be taken in 1984.

Current policy efforts aim at equipping schools further with hardware (microcomputers as well as audiovisual aids) and developing teacher training provisions. Software development has started with the private sector indicating their readiness to adapt and develop software for educational purposes. It is not uncommon in Iceland to make use of textbooks written in English or in one of the Scandinavian languages, especially in the upper secondary schools; the same will apply to software.

Compulsory Education

Equipment - Park	Several schools are equipped.
Equipment - Financing	So far, the equipment has been financed by the local authorities.
Teacher Training	Several courses in computer studies have been offered at the University College of Education.

Secondary Education

Equipment - Park	Virtually all secondary schools have one or more microcomputers

Curriculum - Computer Science	Typical courses of four hours a week, for 34 weeks are run at the first two years of upper secondary school.
Software - Production	Software comes mainly from commercial sources.
Teacher Training	Courses in computer education have been offered to teachers at the University of Iceland as well as in-service courses in several schools.
Access to Data Banks and to Telematic Networks	At present there is considerable interest but no plan.

Trends for the Future

A development plan exists aiming at financing every school of the country with at least a couple of microcomputers.

It is envisaged that informatics and computer literacy will be included in the compulsory school curriculum, although the exact content is still to be determined.

A development plan exists also for the new audiovisual technologies. The Ministry of Education has set up an advisory group on the use and impact of the NIT on the schools. The group is headed by a computer expert from the University of Iceland and includes representatives of teachers from the compulsory and the secondary levels.

The National Centre for Educational Materials will develop software in accordance with the new computer curriculum plan, for compulsory schools. Software for the other stages will be developed, adapted or used in the original language.

Some in-service courses for teachers for all grades have been offered at the Universities. A considerable increase is planned in this area.

IRELAND

Background Information
(EC, 1983)

1970 An International Conference organised by the OECD launches the debate on the introduction of the NIT in education.

First efforts concentrated on in-service teacher training.

1973 The Computer Education Society of Ireland (CESI) is created. The Society publishes a periodic Newsletter and receives grants from the Department of Education.

During the decade 1970-1980, significant industrial developments took place in the country: the resulting demand for trained personnel exceeded by far the capacity of the educational and training system. Some schools purchased computer equipment out of local or private funds.

1978 An indigenous Irish computer group initiates an annual "Memory Ireland Computer Competition" which is open to all schools and provides opportunities for pupils to present individual and group projects on topics relating directly to computers and their applications.

1979 The Ministry of Education established an Advisory Committee to study the introduction of the NIT in education taking into account the existing institutional structures and conventions.

1980 The White Paper on Educational Development was published which announced formally that computer education would be introduced into secondary schools.

As an interim measure the Department of Education establishes an introductory course in Computer Studies in the Senior Cycle programme, as an optional component of the mathematics syllabus. Seven per cent of secondary schools were involved in 1980-81. During the subsequent two school years the figure grew to 20 per cent and then to 37 per cent.

1981 In November the Advisory Committee submits its report to the Department of Education. It recommends:

-- A familiarisation course in NIT to pupils at the junior cycle;

-- A course in Computer Studies of a general nature at the senior cycle level;

-- A number of vocationally oriented courses for particular groups at senior cycle;

-- A general briefing course for senior cycle level not taking Computer Studies as a full subject.

1982 An equipment policy for secondary schools is started by the Department of Education under a bulk purchase system.

Current Situation

The educational system is still evolving under the primary demand for a technologically educated labour force. The secondary cycle is the one considered at the policy level. Efforts cover curriculum development, teacher training and equipment. No policy exists as yet for software production or diffusion.

No developments exist or are foreseen for the primary cycle.

Primary Education

Equipment - Park	Only one school has publicly-financed computer equipment, i.e. a school associated with a primary teacher training institution. It has been supplied with a microcomputer for experimental purposes.
Curriculum - Computer Appreciation	Primary school pupils are made aware of the role of the computer in modern society, in the programme for Mathematics, Social and Environmental Studies. Educational visits to local industries are arranged occasionally during the school year.

Secondary Education

Equipment - Park	Over two-thirds of general secondary schools have computer equipment.
Equipment - Financing	Most equipment is purchased with funds from the Department of Education. Some schools have purchased supplementary equipment with private funds.
Curriculum - Computer Science	Currently pupils from about 350 schools take computer studies as an optional module at the Mathematics "O" level.
Software - Production	A standardised version of the COMAL 80 computer language has been made available to schools to facilitate (a) portability of software, (b) development of good standards in programme design.
Teacher Training	Initial teacher training courses are organised by universities and teacher training colleges. Trainee teachers in Science, Mathematics, Commerce and related subjects are given courses in NIT. In addition some universities offer part-time post graduate courses in Computers

which are attended by teachers. In-service courses in computers are organised by the Department of Education. Attendance at these courses is voluntary. The majority of the lecturers on these in-service courses are themselves teachers. Approximately 5 per cent of all secondary teachers have attended these courses.

Vocational Education

The situation is currenty under review following a report of an Advisory Committee. Some vocational courses, e.g. courses orientated towards office skills, have relevant aspects of information technologies as course elements.

Trends for the Future

Primary Education

It is intended to establish pilot projects on the use of computers in primary schools.

Secondary Education

All secondary schools will be equipped with computers. The use of local area networks is being investigated.

ITALY (EC, 1982)

Current Situation

In a country where major educational reforms have been debated in Parliament over the recent years, it is perhaps no surprise to find that no overall national policy exists as yet to introduce the NIT in education. The vocational and training sector is the only one where some policy developments have taken place, mostly in connection with the training of specialised manpower.

The absence of formal initiatives by the state outside vocational education is, however, counterbalanced by the existence of a number of experiments by single schools, research institutes and local (regional, provincial and municipal) authorities. Studies on the educational applications of video-discs are carried out by six research institutes as well as the education department of state television. Educational applications of computer technology are being investigated in nine university centres as well as in some local education authorities.

Teacher training provisions in this area are very scarce and limited, so far, to teachers of scientific disciplines.

LUXEMBURG

Current Situation

Efforts to introduce the NIT in education are concentrated on introducing courses of informatics at the secondary educational level, and especially the vocational schools. One of the reasons for the discrimination has been one of convenience. The introduction of a new course in the curriculum needs that curricular time be freed for it. The recent reform of vocational education has created the right opportunity for informatics. The situation remains difficult for the general schools where no similar large-scale curricular reforms are envisaged for the time being.

Nothing is done or planned for primary schools.

Secondary Education

Equipment - Park	Twenty-five per cent of the 25 schools have computer equipment.
Equipment - Financing	Mostly the Ministry of Education, partly from the "administration des bâtiments publics" (crédits de premier équipment).
Target Group	Grades 12 and 13.

Vocational Education

Curriculum - Computer Science	Informatics courses take two hours a week for Grade 11 and between two and four hours a week for Grades 12 and 13, for a total of 36 weeks. Programming is taught only at Grades 12 and 13.
Software - Production	The only existing software has been produced by the teachers for their own courses. Their number is unkown.
Teacher Training	The only existing provisions are for initial training of "informatics" teachers

Trends for the Future

General Trend

A development plan has been established by a consultative committee appointed by the Ministry of Education and involving representatives of the Ministry itself, of teachers and the private sector. Their three year plan aims at equipping, by 1986, all secondary education establishments (vocational and general) with a standard computer configuration of 16 independent microcomputers installed on special premises. The budget is established at BF 60 million over three fiscal years.

The Ministry of Post and Telecommunication is testing the introduction of the LUXPAC network in Luxemburg. This could add a new dimension to the use of NIT in education.

THE NETHERLANDS

Current Situation

A coherent national policy on education and the new information technologies, planned to be implemented in the next few years, is currently under development.

Primary Education

Equipment - Park	140 primary schools (1.6 per cent of the total number) have any computer equipment for a total of 184 microcomputers.
Equipment - Financing	The equipment is financed out of the normal schools budget with some gifts by parents.
Target Group	Normal children and children in special education.
Curriculum - Computer Science	No computer science course as such is foreseen for primary schools although the logical principles of programming are being introduced through LOGO activities.
Curriculum - Computer Appreciation	Currently under study within the development plan.
Software - Subject areas	Mainly basic skills, partly remedial education and games.
Software - Production	Courseware created by primary schools stems mostly from the ongoing experiments within these schools. As these experiments are usually manned by universities these are also the producers of most of what exists. Educational publishers have started developing courseware for primary education, but only on a very small scale. Teacher training institutions for primary schools are not involved as yet in any courseware development.
Software - Diffusion	The Centre for Education and Information Technology has started its task as a clearinghouse for educational institutions.
Software: Quality Control	Absolute standards to evaluate software quality are not available. The quality of the courseware developed within the school-based experiments ranges from sufficient to very good.

Software - Transferability	No formal agreement exists between courseware writers and computer constructors. Although recognising the importance of the issue, no policy choice has been made so far by the authorities concerned. At the research level, a project is under way aiming at developing an intermediate language, a language between higher order computer languages of any kind and machine languages of some limited types
Teacher Training	No initial or in-service training on computers is provided, although some foundations have facilities for training. So far only very few teachers have followed these courses.

Secondary (general and vocational) Education

Equipment - Park	695 general secondary schools (46 per cent of the total number) have some computer equipment as well as 191 lower vocational schools (14.8 per cent of the total number) and 317 vocational schools (55 per cent of the total).
Equipment - Financing	The equipment is primarily financed by the ministries of education and economic affairs. In some cases and especially in general education, parents' organisations have raised funds.
Target Group	Normal pupils within the context of regular teaching.
Curriculum Computer Science	No courses in computer sciences are available in general education: this is seen by many experts as a desirable development. In technical and commercial vocational education computer science is taught for one hour a week, for 40 weeks a year, and is meant for pupils who will not take up computer activities as a career. The programme involves insight into computer and information systems, applications of software and data bases, problem recognition and programming.
Curriculum - Computer Appreciation	An educational programme aiming at making pupils aware of the political, sociological and psychological problems of "computerisation" of society is under development.
Software - Subject Areas	Mathematics, physics, chemistry, Dutch and foreign languages.

Software - Production

The existing courseware has been developed mostly by teachers without the involvment of any central institution. Teacher training institutions are starting activities in courseware development.

Software - Diffusion

Since the beginning of 1983, the Centre for Education and Information Technology is operating at a national level. Its objective is to gather and disseminate information, to create a clearinghouse for software, to create and develop software, to organise demonstrations and courses, to co-ordinate activities.

Teacher Training

Some courses are available in initial training in the training institutions. Attendance is voluntary. They involve learning about computers, their applications and their societal implications, programming and didactics of computer education.

In-service training courses are organised primarily by the Ministry of Education and some central organisations. Attendance is voluntary. Programmes are similar to those available for initial training.

Trends for the Future

General Trends

In January 1984 the Ministers of Education and Sciences, of Economic Affairs and of Agriculture and Fishing Affairs, published a white paper, the "Informatics-Stimulation Plan" (ISP), stating the policies for the 1984-1988 period. A total investment of Gld 1 272 million will be devoted to the development and application of information technology, with Gld 267.5 million earmarked for education, to achieve the two objectives of making all citizens acquainted with the NIT and create "human capital" to strengthen the market sector. The larger share of the investments (65 per cent) will go to policy developments mostly in the Vocational Education sector with some investments in primary and secondary education. The remaining resources will be invested to create a national, and partly regional, infrastructure for the development and distribution of software (15 per cent of total expenditure), to inservice (11 per cent) and initial (6 per cent) teacher training, and to educational research (4 per cent). The intent of such initial investment is to attain by 1988 a situation in which educational institutions, industry and other institutions of continuing education, are able to penetrate the remaining part of the educational field without further support. During this initial phase, the Minister of Economic Affairs will focus on assisting the industrial sector in the development of the hardware, software and courseware needed in education and in supporting experimental projects resulting in practical experience and which will have a demonstrative effect.

Primary Education

Small-scales experiments with LOGO were carried out in the summers of 1982 and 1983. An evalutation will be available in late 1983. The development plan currently under discussion foresees a number of experimental projects for primary and special education over a period of four years. The objective of the projects would be to study the new content of education in the new information technologies.

The attitudes of both parents' associations and teachers' unions are rather ambivalent with respect to computers in primary education. The awareness that the new information technologies are getting a stronger hold in education is not always valued positively, because of dependency arguments as well as principles.

NEW ZEALAND

Current Situation

Two basic ideas are at the basis of New Zealand's approach to the introduction of the NIT in education (New Zealand, 1982):

-- The preparation of all students for a technology oriented world: "all students should have the opportunity to learn about the uses and implications of computers and associated technologies so that they may be better informed to contribute to, and have an influence on, applications of the technology in the future.";

-- The definition of the computer as a teaching aid: "the computer can became another aid to the teacher performing certain tasks more effectively than could be done otherwise".

Current policy efforts are concentrated on secondary education. Concern with the primary level is, for the time being, deferred.

Primary Education

Equipment - Park	About 10 per cent of the country's 2 200 schools have computer equipment, mostly used for drill and practice. 2.5 per cent of the schools have video equipment
Equipment - Financing	Computer equipment is purchased through parents' donations to school funds
Teacher Training	Training is not generally available to primary trainees or teachers, except as optional or voluntary activities at teachers' colleges

Secondary Education

Equipment - Park	About 97 per cent of the 391 secondary schools had at least one microcomputer in October 1983. The average number of computers per school is almost 5. The equipment is used mostly for familiarisation and awareness courses at the lower level and for programming and computer assisted learning activities at the upper secondary level. About 96 per cent of the schools have video equipment.
Equipment - Financing	Computer equipment is purchased by schools through funds raised by staff, pupils and parents.

Curriculum - Computer Science	An option exists within Form 7 Applied Mathematics. The time allocation of 80 hours can be spread over a year, or only six months. A fuller (160 hours) course in Computer Studies is offered as a Sixth Form Certificate option in an estimated 167 schools.
Curriculum - Computer Appreciation	Computer awareness appears as a unit of study in Form 4. The course, of 12-30 hours, is offered by approximately 278 schools. A few schools offer full or half-year courses at Form 3 and 4, covering material in greater depth. Information on the societal implications is also given within the social science curriculum.
Software - Production	Some commercially available material, prepared overseas, is used in schools. However, most courseware in use has been written by individual teachers, informally, for use within the teacher's school. A little has been produced in teachers' colleges and universities. Experimental courseware has been developed by the Department of Education, using teachers and a private software firm, to provide trial material for the schools involved in the "Poly" microcomputer project. A computer courseware development unit is to be established within the Department of Education in February 1984.
Software - Diffusion	A number of user groups and computer education societies exist and are the main means of access of schools to courseware. Department of Education courses also help. The main obstacles to further development are geographic: the school population of the country is widely dispersed
Software - Transferability	Following an evaluation of hardware in 1982, five microcomputer models were named as suitable for use in secondary schools. It is the intention to standardise on a language common to the five machines for the purposes of software production and distribution.

Teacher Training	Massey University offers a third-year level diploma of education paper in computer assisted instruction. Teachers' colleges offer a variety of content and methods pre-service courses for teachers.

SWEDEN

Background Information

1980 Completion of the project DIS whose objectives were to establish a computer appreciation syllabus and to study possible subject-related computer utilisations. Main conclusions from this project were that:

a) Computer appreciation syllabus should be established at senior level of compulsory school (Grades 7-9). Instruction should be integrated in mathematics and social subjects and does not require computer equipment. Other levels were not discussed;

b) Subject-related computer utilisation (practical illustrations of the use of computers in fields related to the subject, including subjects in vocational education) should be integrated in subjects within upper secondary school (Grades 10-13).

1982 The project PRODIS (Software and Computer Equipment in Schools) with the objective to specify functional requirements for software and hardware to be used in upper secondary schools was completed. Requirements were separated for different subject areas and were intended to be a basis for purchase of equipment in the communities and to indicate the eventual need for production of software for schools.

As part of this project software produced by teachers and teacher trainers in applied technical courses have been collected by an advisory group and distributed to all schools with the fourth year of the technical line.

1983 The project PRINCESS (Project for Research on INteractive Computerbased Education SystemS) was completed. PRINCESS studied how, and if at all, teaching and learning could be improved with the use of computers as aids, where students and teacher have the initiative and control. A model of such use has been developed and tested. The model is a complete system including computer aid and its relation, for example to teaching materials and other equipment, instructional planning and the training of school staff. Empirical studies were performed at upper secondary level, but the results can be valid also for Grades 7-9 in compulsory school.

A coherent programme on computers in school and adult education has been started by the National Board of Education.

Current Situation

The Swedish approach to the introduction of the NIT in education is a typical one of policy decisions taken on the body of experimentation and research. The current programmes focus on computer appreciation courses as well as on the use of computers in upper secondary school. In total, activities have started in two-thirds of the Swedish schools. But there is more activity in upper secondary schools than in compulsory schools. Up to now there has been no apparent strong difference of investments in the general or vocational options. There is almost no use of computers as aids for teaching. Policies are implemented through compulsory directions in the curriculum. In-service training for teachers on computers has in two years increased from some hundreds to 6 000 participants in courses of 2-5 weeks' duration. The local communities are responsible for the in-service training which can be organised locally or be given as university courses. Software is supposed to be developed by producers of teaching materials and other software houses. The availability of good software has to be increased but also the willingness of purchasing software for educational purposes. In total there are 9 000 computer work stations in Swedish schools (overall average of nine per school with reported activity).

Compulsory Education

In agreement with the recommendations of the DIS project, no computer equipment for teaching computer education has been introduced at this educational level through grants from the government (in spite of this many municipalities bought computers for their schools). The decision was made partly for financial reasons but also for reasons connected with the subject itself as no consensus exists as to the value of introducing BASIC programming at this stage.

In the new curriculum for the compulsory school, which is followed since 1982, information and discussion about computers and their effects are compulsory items in the syllabi for mathematics, social and science studies. About 50 per cent of the compulsory schools at senior level report activities.

Equipment - Park	About all schools with activities have between one and eight, in general rather primitive, microcomputers. The average number is five micros per school.
Teacher Training	A number of local initiatives have been taken in order to give in-service training to teachers in computer education. A number of teachers have attended 2-3 week courses at the university. The government is planning special measures for in-service training for teachers in compulsory schools for the period 1984-1987.

Secondary Education

Equipment - Park	Almost every secondary school (Grades 10-13) has access to a computer. In general, schools with technical lines have better computer equipment than others.

In 1981, about 15-20 secondary schools had minicomputers with over 100 k word primary memory, each with 10-20 terminals. Additionally, almost every secondary school had 1-30 microcomputers with 16-32 k word primary memory.

In many cases the micros are organised in local networks. On the average there are 20 computer work stations at the secondary schools with activities (70 per cent of the total number of secondary schools).

Traditional audiovisual equipment exists in virtually every school. But audiovisual material linked to a computer hardly exists.

Equipment - Financing

Computer equipment is mainly financed by local authorities. Since 1982/83 there has been a limited state support.

Curriculum - Computer Science

There is no specific training for computer-career pupils, they receive the same training as others. Some more computer oriented education is available. In natural science lines a certain computer oriented subject can be choosen as an alternative. This subject is taught two hours a week in Grade 2 and six hours a week in Grade 3. As a complement after upper secondary education is finished, most of the students can choose between different courses that offer computer oriented specialisation. The duration of such a course is usuallyof one year.

Curriculum - Computer Appreciation

As a continuation of the computer appreciation syllabus within compulsory education, computer appreciation shall be taught at Grade 1 within mathematics and civics, at least 20 hours of study in all lines. Most of the schools were teaching computer appreciation in 1983, but not to this extent.

Due to lack of software in schools the use of computers in different subject areas are still rather limited. The available hardware is in many cases too primitive for use of applications such as bookkeeping and word processing.

Software - Production

As part of the PRODIS project, programmes made by teachers and teacher trainers in applied technical subjects have been collected by an advisory group and distributed to all schools with the fourth year of the technical line (37 schools).

A certain amount of development concerning programmes for computer appreciation and subject-related computer utilisation (mathematics) is being financed by the State. These programmes are freely available to schools.

Other programmes used have been produced commercially.

Software - Diffusion

The most successful example of pooling and distributing software has taken place within the PRODIS project. Other attempts to diffuse software produced by teachers have not been very successful so far due to the unwillingness of teachers to part with their products.

Teacher Training

A reform of in-service teacher training as a whole took place in summer 1982. Experimental activities have been undertaken whereby universities now offer courses where compulsory school teachers are given three weeks' training and their upper secondary colleagues follow training for at least five weeks, with no reduction in salaries. Training is tied to curriculum. Teachers from compulsory schools, where mainly computer appreciation is taught have their courses focused on this part, whereas the extra two weeks for teachers from upper secondary schools also include subjects related computer utilisation. Attendance is voluntary, and can be either part- or full-time. So far about 6 000 teachers have been formally trained.

The objective is to train all teachers responsible for computer appreciation at compulsory school and secondary teachers who teach mathematics, social subjects, applied technical and economical subjects and other vocational oriented subjects (altogether approximately 30 000 teachers).

Trends for the Future

Based on the functional requirements set up in PRODIS a technical procurement project was started in 1982 by the National Swedish Board for Technical Development. This has resulted in a Swedish computer that will compete with other enterprises for the schools market. Five communities have been involved in the project. The government has allocated specific funds for the project. The total expense per annum for teacher in-service training is calculated to SKr 50 million.

The National Board of Education has, as part of the coherent programme on computers and education, developed a policy for the future work within this area. A perspective of the computer technology as part of a larger system shall be applied. It shall be a goal to minimise gaps in the future society, such as gaps between sexes, different groups, between parents and children. Education has to be actual and of high quality to be accurate. As a consequence continuous revisions of curricula have to be done, equipment and software must be flexible and ambitious and repeated in-service training of teachings is necessary. The use of computers as aids in education is recommended to apply the pedagogical approach that was used in the PRINCESS project, which is not the programmed learning approach. Concerning the primary level, no suggestions will be made before more results from research are available.

UNITED KINGDOM

Background Information

Microcomputers in Education

1960s The interest in computer-related systems develops at first in higher education establishments.

1965 Computers are installed in schools under pressure of motivated teachers, supported by national organisations.

1970s Essentially a development decade, marked by the Government-funded UK development programme with a prime emphasis on cost effectiveness and institutionalisation of computer-based learning, mainly in higher education.

1972 Schools across the country started developing computer appreciation courses, and some, assisted via computer centres in colleges or authorities, began using computers in different subject areas. In England and Wales, a project on "Computers in Curriculum" got under way. The two "Bellis" reports set the patterns of development for the decade, recommending, among others, that computing as a separate subject be rejected in favour of the use of the computer in other individual subjects, and that computer appreciation be taught to all pupils aged 14-16.

1979 Microcomputers began to appear in schools. The Scottish Education Department (SED) funded by the Scottish Microelectronics Development Programme (SMDP), aiming initially to act as a focus for development work with micros in schools (primary and secondary, including special schools, and in further education institutions). This was a development separate from the Mocroelectronic Education Programme (MEP) in England and Wales, which began in 1980. Both emphasized in different ways the development of the use of the microcomputer in the curriculum as a learning resource, and the stimulation of new elements in the curriculum to reflect the widespread use of new technology in society.

1982 The "micros in schools" equipment subsidy schemes of the UK Department of Trade and Industry began to be implemented simultaneously in England, Wales and Scotland. These schemes cover all primary and secondary schools (including independent schools).

The UK Government announces an Information Technology (IT) programme aimed at creating new student and research posts in universities and higher education institutions, and budgeted to spend £38 million over 3 years (1983-86).

Current Situation

The most important and coherent effort to introduce microcomputers to the schools of England, Wales and Northern Ireland remains with MEP. It has three principal areas of activity: -

- Providing information and advice thorough 14 regional centres;
- Facilitating the LEA provision of teacher training;
- Developing materials, software and hardware for the curriculum.

In Scotland, in 1983, SMDP formally became part of the Scottish Council for Educational Technology (SCET) to be indefinitely funded, with from 1984 a national (Scottish) responsibility for a software library, information service, and the promotion of research and development in association with the Scottish Education Department and other funding agencies. The emphasis of the recent work of SMDP has been on software development.

Other New Technology Developments

In the mid-1970s secondary schools began to be equipped with videorecorders and the level of use of school broadcasting increased proportionately in these schools. Primary schools meantime maintained a high level of use of radio and TV "off-air".

With the advent of cheap videorecorders the pattern of use changed and nearly all secondary schools now have more than one videorecorder, and almost a half of primary schools. There is a high use of educational broadcast material from the BBC and ITV and increasing use of video production facilities in schools.

Open learning developments, beyond those pioneered by the Open University, began in teacher education in Scotland in the mid-1970s and across the UK have recently expanded rapidly in many sections of post-compulsory education. This was aided significantly by consultation and advisory support at CET (Council for Educational Technology for the UK), and stimulated by other projects including those now under the UK Open Tech Programme. The Open University has continued to pioneer NIT to support its courses.

Primary Education

Equipment - Park	As at December 1983, 43 per cent of schools were equipped with 1-2 microcomputers, mainly BBC, but with some Sinclair Spectrum and RML 480Z. With the implementation of the scheme from the UK Department of Trade and Industry (DTI) this will continue to increase rapidly to above 90 per cent by 1985.
Equipment - Financing	Computer equipment and peripherals financed mostly by central government funds matched by schools, with extra equipment obtained via school funds or gifts.
Target Group	Pupils of all abilities. Distinct attention given to children with special educational needs.

Curriculum - Computer Science	Computer science does not feature in the primary curriculum as a "subject", but some children are able to program.
Curriculum - Computer Awareness	No special provision exists within the primary curriculum but awareness of the computerised society will be stimulated through topic work covering language arts and environmental studies.
Software - Subject Areas	Across the curriculum interest, with a wide range of developments extending the horizon from "traditional" drill and practice to simulation, open-ended decision making, and data-base work. Links with school broadcasting output. Primer kits of software were provided for all UK schools acquiring micros under DTI schemes. There are also simple word processors and text editors specially designed for the primary curriculum.
Software - Production	A good deal of software has been written by teachers, some seconded to software production units. The SED has a £200 000 primary schools software production project via the SMDP and in conjunction with Local Authorities. There is a further DTI project, and via authority-based and college-based groups other material is appearing. UK-developed commercial software is making an increasing impact, where production costs are being paid by the publishers.
Software - Diffusion	The commercial publishers are having a growing impact as suppliers to schools which are purchasing material out of their own funds. These is still a shortage of software.
Software - Quality Control	There is no formal agency fullfilling this function. Some education authorities have formed evaluation groups of teachers and advisers which link with MEP and SMDP. These are seen as focuses for documentaion and production standards.
Software - Transferability	SMDP software is provided in versions for use on BBC, Spectrum and 480Z machines (those available via the DTI scheme), and this parallel production is becoming more common.
Teacher Training	Pre-service: in Scotland initial training in computer appreciation is given to all students, with the additional option of more specialised training (implications of computers, their use

	within the curriculum, and normally, some programming). In-service: all UK schools in receipt of DTI-subsidised equipment have to have staff trained (short awareness, handling course). Probably about 10 per cent will have attended these courses, or others run by education authorities and colleges, of which there are an increasing number. Some staff have attended longer courses via colleges or the Open University. Attendance is either part-time or full-time and always voluntary. In England and Wales, MEP have a unit to support teacher education. In Scotland a development plan to extend in-service training further is under consideration in conjunction with the software developments.
Access to Data Banks and to Telematic Networks	There is an increasing interest in telesoftware distrubution via broadcast and telephone routes (via PRESTEL), but this has still to develop in conjunctin with primary schools. Data banks are still at a development stage.

Secondary Education

Software - Diffusion	The software library at SMDP is developing its primary component. The commercial publishers are having a growing impact as suppliers to schools which are purchasing material out of their own funds. There is still a shortage of software.
Software - Quality Control	There is no formal agency. Some education authorities have formed evaluation groups of teachers and advisers which link with SMDP, which is seen as a focus.
Software - Transferability	SMDP software is provided in versions for use on BBC, Spectrum and 480Z machines.
Teacher Training	Pre-service: initial training in computer appreciation is given to all students, with the additional option of more specialised training (impliciations of computers, their use within the curriculum, and normally, some programming). In-service: all schools in receipt of DTI-subsidised equipment have to have staff trained (short awareness, handling course). Nearly 3 000 teachers (about 10 per cent) will have attended these courses, or others run by

education authorities and colleges, of which there are an increasing number. Some staff have attended longer courses via colleges or the Open University. Attendance is either part-time or full-time and always voluntary.

A development plan to extend in-service training further is under consideration in conjunction with the software developments.

Access to Data Banks and to Telematic Networks

There is an increasing interest in telesoftware distribution via broadcast and telephone routes, but this has still to develop.

Secondary Education

Equipment - Park

As at December 1984, over virtually all secondary schools had microcomputers, with an average of 5-10 used by at least 4 members of staff. Some schools have more than 50.

Interactive video is only being used in research contexts, but the use of micros as presentation devices is growing as better graphics capabilities have become available. This is an area expected to expand.

The main peripheral developments are in interfacing and control, and the use of programmable instruments in science courses. Individual teachers are experimenting with modems for telesoftware and electronic mail.

Equipment - Financing

The DTI scheme provided schools with one micro, and the remaining majority have been bought by Educational Authorities or by schools out of their own funds. At the same time authorities are re-equipping schools with video-recorders, usually in VHS format.

Target Group

All pupils.

Curriculum - Computer Sciences

No distinction is made in provision between pupils who will take up a computer-based career and others.

Examinable courses in computing have developed in different ways across the UK at 16+ and beyond. In England and Wales there was a substantial growth in numbers taking these courses in the last decade. Exact future arrangements are not clear, given reorganisation of 14-16 age group courses and changes at 16+. In Scotland the Action Plan provides several "modular courses", opportunities in computing, some of which will probably be used in schools, and which relate directly to post-school training wherever provided.

Curriculum - Computer Appreciation

"Computer Studies" courses, covering awareness, applications, uses, and effect on society has a history going back over twelve years. They do not have a vocational emphasis but include programming skills. They are being increasingly provided but to different degrees for pupils aged 12 and over. In Scotland a recent set of curriculum guidelines for courses for the first two years of secondary education (ages 12-13) have had a significant effect on course development.

Computer clubs are extremely popular in schools and offer access for pupils of all ages at intervals during the day and after school, though mainly by boys.

The political, sociological and psychological problems of computerisation in society are considered in number of social subjects courses; courses related to the industrial society and in business studies.

Software - Subject Areas

Main application areas are in mathematics, science, geography, modern studies, modern languages and in remedial education, but there are developments in course content and in the use of micros to support teaching in most subjects, and increasingly so. The over 500 programs developed via MEP and SMDP are primarily aimed at assisting learning and teaching across subjects.

Electronics and micro-electronics are being introduced as new courses or subject elements, with associated software, and associated use of interfaces and programmable peripheral devices.

An example of a major project is the one at the Esme Fairbairn Research Unit (Heriot Watt University), which involves a simulation of the British economy. This is used for teaching macro-economics in the final year of schools and in universities. It forms the basis of a UK-wide competition for schools and has been adopted as a teaching package by a range of large oil, electronics and shipping companies.

Software - Production

The computer education centres in the Colleges of Education, and in education authorities, which have existed for several years, have moved quickly into adapting their work and packages for micros. Some of this is in conjunctin with MEP, SMDP and curriculum development projects. Teachers have been seconded and provided with programming support. Some commercial software is available.

MEP allocates sums via its regional centres to encourage and develop software production from schools and colleges. There is also a lot of "cottage industry" programming by teachers. Education authorities support a range of smaller centres, building upon the activities of subject-related teacher groups. A DTI software development scheme will provide further subsidised production, at a UK level.

Various research projects are developing packages, including assessment and in particular, in Scotland, for classroom use of item banking and for achievement testing.

The Schools Computer Administration and Management Project (SCAMP) will allow educational authorities to provide from a single data base housed in a powerful micro, all the administrative needs of a secondary school. It is being developed at SMDP and tested in several authorities. Smaller scale, interim, administrative support programs are being produced by interested schools and by authority centres.

Software - Diffusion

MEP operates regional centres and SMDP in association with education authorities and colleges operates a system of distribution centres for its software. Commercial publishers are providing a growing amount of material.

Schools are beginning to experiment with telesoftware distribution via Prestel and through the BBC broadcast teletext CEEFAX service, in association with school broadcasts.

Software - Quality Control

Although there is no organisation formally charged with controlling software quality, MEP/CET and SMDP perform this function and have issued documentation and programming standards. Local teacher evaluation groups exist with specific subject interests.

Software - Transferability

Most centrally funded software is made available on at least two formats, usually BBC Basic and either Apple, Sinclair Spectrum of RML 380Z compatible.

Teacher Training

Pre-service: voluntary initial training courses in computers are offered to almost all trainee teachers but the arrangements differ across the UK. In parts, e.g. in Scotland, compulsory courses are generally given to teachers of mathematics, business studies, the sciences, geography and other social subjects (covering computer appreciation and the effect on their subject). All such courses are provided by teacher education colleges. The number of hours given can range from 30 to 300 depending upon the subject. The number of teachers being trained in this way is declinng as recruitment to teaching reduces.

In-service: under the DTI equipment scheme two teachers per school underwent short courses of training. Further provision here is by education authorities alone, or, more usually, through colleges of education, and in England and Wales in association with MEP. Training is voluntary and would normally consists of hand-on experience, introduction to programming, and the application of computers in specific subjects. There have been some subject-based courses. Beyond these, establishments are providing more advanced courses in computer studies, computer-based learning, electronics, control technology, communication and information systems. Some of these are in association with MEP.

The number of teachers involved is increasing and totals more than 40 000. The trainers involved are college lecturers, or education authority staff recruited from practising teachers. Development plans for this area of training are under study, and further staff in computing are being recruited for colleges.

Access to Data Banks and to Telematic Networks

CET and SCET run both a public data base on Prestel with CET taking the lead. CET acts as an umbrella organisation in association with Prestel. It piloted telesoftware distribution and was responsible for defining protocol standards, and is now developing an education service.

SCET also operates a private viewdata system.

This is being used for electronic mail and interactive communication by schools in parts of Strathclyde Region, on an experimental basis. It is also the focus for a DTI-supported electronic information exchange among teachers in special education establishments.

Centrally-funded projects using databases or electronic exchange include item-banking, computer-assisted careers guidance, SCAMP (for school administration), geography data, and the Educational Broadcasting Database project in conjunction with the British Broadcasting Corporation and the Independent Broadcasting Authority.

Only a few schools will have contact with major public databases such as BLAISE, ERIC -- except via colleges or libraries.

Trends for the Future

General Trend

In England and Wales the MEP will continue to support LEAs and schools in their information and teacher-training functions until 1986. Thereafter LEAs will be expected to take over and run these activities. No decision has yet been taken on whether there will be continuing support via the MEP for software production after 1986.

CET is continuing to put a major part of its exploratory work in the new technologies, including interactive video.

In Scotland SMDP is now on a permanent basis as part of SCET, and is providing a national centre for support of software development and distribution, information, and the promotion of research and development.

The Alvey report and research council recommendations are expected to influence the increased interest in research in microcomputers and the curriculum at UK level.

Other enquiries, including in association with MSC-funded developments, cover the increased use of other individualised and open learning approaches, and media, as a consequence of the other changes in curriculum and assessment for the 14-16 age range and the 16+ students (including adults) not in higher education.

In addition to supporting work at SMDP, the SED is funding a range of research projects in primary and secondary education including the effects on school building provisions, and their use, of the introduction of new technologies.

Primary Education

There is likely to be an increasing emphasis on research and development in microcomputer applications in the use of language, mathematics, and environmental studies. There are developments in Logo including Logo data bases and an "infant Logo" using a "concept keyboard".

The further introduction of peripherals, including "turtles", and the use of cheap wordprocessing ROMs, are likely to be areas of change in classroom practice, the last particularly in relation to language skills development.

Secondary Education

The future equipping policy now lies with the education authorities though there are centrally funded peripherals and software production schemes under consideration.

Increasing software production, the use of a variety of peripherals and interfaces, and the interest in use of micros to support administration, are also likely to have major impacts on classroom organisation and practice.

The access to data banks is an expanding area using a variety of modems with BBC and other microcomputers for software exchange, and for electronic mail applications. This is an aspect on which CET have placed considerable emphasis, and have encouraged the piloting of systems which match the needs of schools and colleges.

Special Education

The next DTI equipment support is the UK provision of free microcomputer equipment for special education establishments, together with a MicroSpecial Pack for support and teacher education.

UNITED STATES

Background Information

The current US federal involvment in education and the new technologies can be traced back to the general development of federal policies and intervention in science and technology. The trend has been essentially cyclical. It started towards the end of WWI with the Bush Report (Science - The Endless Frontier) establishing the development of scientific talent as a federal responsibility. Aimed first at identifying the "talents" in higher education establishments (the federal programmes of grants and fellowships to students who had already chosen a science career) the policy approach changed subsequently from one of aid to the few already visible talents to one of large scale research and development of the science potential within the population. The federal intervention then took the form of teacher training programmes and curricular changes at the high school level (N.S.F., 1980).

Federal involvment and expenditure in science and science-related education climaxed in the late 50s and declined in the 60s, when "equality of opportunities" became the main heading in the educational budget. The waning federal interest in science education, and more particularly in computer-related education is illustrated by the variation in budgetary allocations in the past years (Grayson, 1981):

1965	36 per cent of relevant educational funding came from federal sources;
1970	The financial volume fell to 17 per cent;
1980	Federal participation is even lower.

Current Situation

The federal interest in the field is at present rising once more. The target is as before the reservoir of scientific talent within the population. The concern is on the education of an adequate number of specialists for the ecomony of the very near future.

It is too soon to see what specific forms the renewed federal interest in education and the technologies will take. The US situation remains for the time being profoundly marked by initiatives at the state level. If and when the federal government decides to implement a national policy it will find the states' educational systems already penetrated to (sometimes) a very considerable extent by the NIT.

The number of microcomputers available for instructional use by public school students has tripled between Fall 1980 and Spring 1982 and tripled once again by the close of 1983 reaching an estimated figure of 350 000, or about one microcomputer for each 120 students.

In spring 1982, public schools with at least one computer numbered approximately 29 000 out of a total of about 80 000 public schools. Of these schools, 80 per cent had microcomputers only, 15 per cent had both micros and terminals, and 5 per cent had terminals only.

In the second half of 1982 the rate of acquisition of computer equipment by schools accelerated. By January 1983, 53 per cent of all schools in the US had at least one microcomputer used for instructing students, with the distribution of equipment skewed heavily in favour of the secondary level (USA, 1983). The gap between the secondary and the primary schools is currently narrowing.

Primary Education

The objectives pursued include:

- -- Improved student learning;
- -- Improved teacher preparation;
- -- Improved student preparation for modern workforce.

Equipment - Park	In January 1983, 42 per cent of US primary schools had at least one microcomputer, with less than 10 per cent having five or more.
Equipment - Financing	Mostly state and local funds.
Target Group	Pupils of all abilities.
Software - Subject Areas	Most of the software being marketed to US schools is targeted at the elementary school level and built around the premise that microcomputers can be a cost-effective means of increasing the rate at which students learn the basic skills in numeracy and English (USA, 1983). Besides drill and practice, microcomputers are used for general, intellectual development by students using LOGO.

Secondary Education

Equipment - Park	By January 1983, 85 per cent of all high schools had one or more microcomputers and 40 per cent five or more.
Equipment - Financing	Mostly state and local funds.
Curriculum - Computer Science	Computer science varies widely in content and number of hours of instruction. Enrolments in college-preparatory courses in computer science are growing with growth in demand by business and industry. An advanced placement examination is now available as a part of the College Board Admissions Testing Program. Computer literacy is usually taught in 7th, 8th

	or 9th Grades, often for three hours per week for 20 weeks.
Software - Subject Areas	Use of microcomputers in the secondary schools is primarily for instruction in computer literacy, which includes courses in computer awareness, computer programming and computer science. Other uses in mathematics, science and foreign language instruction are growing with improvements and increased availability of suitable educational software.
Software - Production	Little has been funded or produced by state and local education agencies; some has been produced by university faculty funded by the federal government; little has been produced by teachers and pupils. Most is now produced by private sector firms.
Software - Quality Control	The quality of presently available courseware is generally poor and does not take advantage of present knowledge and techniques that could substantially improve quality.
Software - Transferability	Although software compatability does represent a problem for the schools, there is no systematic effort underway to solve it. Operating systems such as CP/M, and run-time hardware interpreters and emulators represent partial solutions now in use. It is anticipated that this rapidly developing technology will evolve new solutions in the future. Until then, rewriting software as necessary is likely to be the solution of choice for software developers.
Teacher Training	There is little agreement on the nature and extent of teacher training required for various educational uses of computers. A considerable amount of teacher training of all kinds is underway.
Access to Data Banks and to Telematic Networks	There is little emphasis in the schools on instructional applications involving access to remote data banks.

Trends for the Future

General Trend

A reasonable forecast for this decade is that the current positive trend will continue: yet more schools will have more computer equipment.

The underlying attitudes are mixed among school staff and administrators. Moreover, they are more determined by beliefs and institutional context than by knowledge of problems and opportunity.

The current variation by states is also likely to continue. Among the most promising state-based developments of the recent years are:

-- The Minnesota Educational Computing Consortium;

-- The National Co-ordinating Center for Curriculum Development (State University of New York at Stony Brook);

-- The Northwestern Regional Laboratory;

-- The CONDUIT Consortium in Iowa;

which are all involved in either/or equipping schools with hardware and producing and diffusing quality software.

Software development remains one of the key issues for the years ahead. A recent survey reveals some 700 private-sector firms engaged in educational software development, most of them small and very small. Approximately 1,650 separate software titles were found in mathematics and science education, 500 in reading and writing, and 500 in foreign language instruction. With the exception of drill-and-practice software in elementary arithmetic and initial reading skills, which often parallels the school curriculum, Grades K-6, the remaining titles are generally stand-alone packages that do not map onto the course syllabus. This creates new difficulties for the classroom teacher in deciding on their timely and appropriate use. There is widespread agreement that only a small number of these titles -- less that 5 per cent -- make use of the unique potential of the computer for improving student learning. Very little software development is presently being supported by State and local education agencies, or by agencies of the Federal Government.

REFERENCES

BRODERICK (1982)
W.R. Broderick, Evaluation and development of computer-related learning systems - experience of the United Kingdom, Council of Europe, DECS/Rech (82) 15

CHRETIEN et MICHEL (1982)
Catherine Chretien et François Michel, Education et Micro-Informatique: deux strategies Euroéennes (Angleterre), Agence Nationale pour le Développement de l'Education Permanente, Paris, septembre 1982

(EC, 1983)
Education and the New Information Technologies:
The Situation in Member Countries (EC, 1983) (provisional draft)

GORNY (1982)
Peter Gorny, New Information Technologies in Education in the Federal Republic of Germany, European Journal of Education, Vol.17, No.4, 1982

GRAYSON (1981)
Lawrence P. Grayson, New Technologies in Education. Invited contribution for the 1981 education of the Encyclopedia of Educational Research, National Institute of Education, Washington D.C. 26th May, 1981

JENSEN (1982)
Torsten Jensen, New Information Technologies and Education in Denmark, European Journal of Education, Vol.17, No.4, 1982

NATIONAL SCIENCE FOUNDATION (1980)
National Science Foundation, Science and Engineering, Education for the 1980s and Beyond, Department of Education, October, 1980, Washington

(New Zealand, 1982)
Computers in Schools: Report on the Consultative Committee on Computers in Schools
Department of Education, Wellington, New Zealand, February 1982

USA NATIONAL SURVEY (1983)
USA National Survey, Center for Social Organization of Schools, John Hopkins University, School Uses of Microcomputers, Reports from a National Survey, Issue No.1, April 1983 (USA, 1983)

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THE INTRODUCTION OF THE NEW INFORMATION TECHNOLOGIES IN EDUCATION: POLICY TRENDS AND DEVELOPMENTS IN MEMBER COUNTRIES

1. The attached note contains an overview of the introduction of the new information technologies in primary and secondary education in the following countries, which were not included in the original document: Belgium, Finland, Greece, Japan, Norway, Portugal, Spain, Switzerland and Turkey.

AN OVERVIEW OF THE INTRODUCTION OF THE NIT IN MEMBER COUNTRIES

PRIMARY AND SECONDARY EDUCATION

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BELGIUM

Current Situation

Characterised by an uneven situation between the French and the Dutch speaking areas. Although comparable in the (scarce) developments at the primary levels, the two parts of the Belgian educational system present marked differences at the secondary level, with the French speaking schools having done much less but preparing a full development plan for the future, and the Dutch sector having done much more in terms of equipment and state investments but without a present or foreseen plan.

In the opinion of the educational authorities concerned (EC report, 1983), the relative slower developments in French speaking Belgium are due to the combination of the relatively unstable political situation of the past three to four years (which brought a succession of changes at the head of the Education Department, the budgetary repercussions of the general economic crisis and the recognised need to carry out a preliminary and thorough feasibility study taking into account the resources (equipment and trained teachers) which could realistically be planned for, so as to avoid the kind of misguided practice which had dogged the introduction of audio-visual methods and programmed instruction in schools some 15 years before.

Primary Education

Equipment - Park	1 per cent of the French speaking schools have computer equipment None has audio-visual equipment
Equipment - Financing	In the French speaking area: -the Ministry of Education -some industries -the schools themselves
Target Group	In the French speaking schools: the underachievers
Software - Subject Areas	Remedial education in the French speaking schools LOGO is experimented at the university level
Teacher Training	In service provisions are organised in the Dutch speaking area by the Ministry of Education. Attendance is compulsory. Teachers learn how computers work and how to programme them. 88 teachers were so trained in 1981-82. They followed a course of six sessions of four hours each on the pedagogical applications of the computer and programming in BASIC. No development plan exists. The trainers are university graduates having followed a course in informatics. They are hired irrespective of

specific expertise in education or teaching. No systematic training provisions exist in the French speaking area

Secondary Education

Equipment - Park

In the French speaking area:

- most of secondary schools (age groups 14-16 and 16-18) have at least one microcomputer. This is used either on an experimental basis or as a learning aid in courses of informatics and management-applied informatics.

In the Dutch speaking area:

- 25 per cent of the schools have computer equipment

- each state school has a "pedagogical and audio-visual centre"

Equipment - Financing

In the French speaking area, the sources of financing are:

- the Ministry of Education

- provincial and municipal public authorities as well as state-aided denominational bodies

- the schools

- the alum associations

- the parents associations

In the Dutch speaking area:

- in 1982, Bel.Frs.30 to 35 millions were invested in computers for secondary education. This represents the totality of costs for state schools and only 60 per cent of it for state-aidod schools
- the audio-visual park is financed according to the same rules

Curriculum - Computer Science

In the Dutch speaking area, all pupils of state schools can attend optional courses (two hours a week) in informatics

Curriculum - Computer Appreciation

Usually integrated within the Social Science curriculum

Software - Subject Areas

In the French speaking area, mostly student assessment by multiple-choice questions, the teaching of programming in mathematics, physics, economics and simulations in economics and industrial technology.

In the Dutch speaking area: problem solving, drill and practice, competitive games

Software - Production

In the French speaking area:

educational authorities, firms, universities, teacher training institutions

In the Dutch speaking area the software used is mostly produced commercially. Teachers are encouraged to produce software for their own discipline

Teacher Training

In-service training provisions in computers are available in the French speaking area. Courses last from five to ten days (for state schools) to ten to fourteen (for the tertiary sector). Enrolment is voluntary but attendance is compulsory. The lecturers come from the "écoles superieures d'informatique"

Access to Data Banks and to Telematic Networks

No access is available to schools. Some research is carried out at the universities of Brussels and Liége

Vocational Education

Curriculum - Computer Science

In the French-speaking area, courses are offered which last for about 30 weeks, with a weekly charge of seven to eight hours for students in the informatics line and of two to four hours for the others.

In the Dutch speaking area, some state schools run a 16 hour a week course in the 5th and 6th year of the secondary cycle

Besides the fuller courses of the informatics line, other schools offer lighter courses (one or two hours a week) during the last two years of the secondary cycle

Trends for the Future

General Trend

In the French speaking area, the committees appointed to study the introduction of the NIT in education identify three main objectives:

- every pupil leaving secondary education must have received a basic training in computer studies;
- holders of diploma in computer studies (obtained via short advanced courses) should be gathered together to form a teaching reserve;
- teachers in technical and vocational education will have to make an extra effort to train the staff needed for the spearhead industries to be estabished under the new industrial policies

To achieve these objectives it is proposed to establish a three-level system architecture:

- a large computer at central level (Data Processing Centre of the Education Department);
- a number of medium-sized computers located at approriate points in the regions to act as relays/back-ups at this level;
- microcomputers at local level, serving individual establishments or groups of establishments.

The Committee also recommends that schools wishing to introduce the NIT should also ensure the availability of suitable staff and premises as well as the computer equipment.

The Committee also feels that the high complexity of the problem of integrating the NIT in education necessitates the existence of a body for systematic co-ordination of teacher training, equipment programmes and monitoring of experimentation.

Primary Education

No development plan exists in the French speaking area. Reactions by parent associations and teachers unions remain mild. Reactions by pupils are in general very positive.

Secondary Education

In the French speaking area, a development plan is being developed, covering fields such as the teaching of the mother language, economics, management, mathematics, physics and technical courses (industry and crafts).

In the Dutch speaking area no overall development plan exists. A committee of experts has been created to follow market developments of informatics and consequently to advise the government on acquisition of computers for state schools

FINLAND

Background Information

1970 Instruction in data processing was started in technical and commercial education institutions (first as voluntary courses).

1980 A project related to computer science in the upper secondary school was set up to examine the need for computer-assisted instruction in various subjects. A curriculum for computer science was prepared. Furthermore the use of computers in educational administration was examined.

1981 A working group was appointed to examine the acquisition of computer equipment and programmes in upper secondary schools.

An information technology project was started with the aim of including basic instruction in information technology in all vocational education by 1987.

1982 A course in computer science was included in the upper secondary school curriculum.

1983 A case study was completed on the production of computer programmes adapted to educational purposes, and a procedure for the approval of programmes for school use was confirmed.

Current Situation

The introduction of the NIT in the Finnish educational system is a very recent phenomenon. In the past only the vocational education sector had been involved and only to a modest extent. The current policy is to start at the upper secondary level and with the vocational sector (itself undergoing a major reform). A short term forecast would see the successful implementation of equipment policies and the persistence of severe problems for software production.

There are no current or foreseeable plans at the comprehensive schools where computer based experiments are run except for special schools.

Primary Education

Virtually nothing exists at this level, with the exception of experiments in special schools. A body of software has been produced within the DIDATA-system (the "talking computer") at the University of Jyväskylä under the supervision of the Bureau for Special Education of the National Board of General Education, and also by private teachers' groups. At present there are some 180 such programmes for primary education

Lower Secondary Education

Equipment - Park	Almost all schools have video equipment
Equipment - Financing	Video equipment is purchased by the municipalities

Curriculum - Computer Science	The basics of computer science are integrated in the mathematics curriculum in Grade 9. In the future they will also appear in technical work classes. Usually the teaching is carried out without any computer equipment Additionally, the comprehensive schools have run for several years "club" activities related to informatics and electronics. These clubs have been able to use computer equipment borrowed from the upper secondary classes, which often share the same premises. These activities have concentrated mainly on programming and the construction of electronic equipment
Curriculum - Computer Appreciation	The courses have been introduced by the revision of the comprehensive school curriculum in 1983, mostly as an integral part of the social science curriculum and the (optional) commercial subjects
Software - Subject Areas	Special education only
Access to Data Banks and to Telematic Networks	There are no experiences nor plans in this area

Upper Secondary Education

Equipment - Park	Computer equipment was introduced massively in 1981. 40 per cent of the schools were equipped during the first year, 30 per cent more by the second year of operation. In 1983 the figure has grown to 90 per cent
Equipment - Financing	Municipalities with state aid, conditional on the purchasing of hardware and software recommended by the National Board of Education
Curriculum - Computer Science	All students receive a five hour training within the Mathematics courses. In 90 per cent of the schools Computer Science is available also as an independent 38 hours optional course
Curriculum - Computer Appreciation	This is included in the "computer science" provisions
Software - Production	A severe shortage of software exists. Some modest production has been made by suppliers and teachers

Software - Diffusion	As from Spring 1983, the National Board examines the programmes, prepared a list of those suited for educational use and informed the schools
Software - Financing	State aid is granted for the acquisition of the software included in the "good quality" list of the National Board of Education
Teacher Training	Courses for teacher have been organised together by the trade union of teachers in mathematics subjects and the National Board of General Education.
Access to Data Banks and to Telematic Networks	Access to Data banks have been discussed but no actual plans have been made There are no experiences of videotex equipment

Vocational Education

The vocational education system will be reformed in 1982-88. One of the aims is to introduce by 1987 basic training in data processing in all basic branches. The estimated expenditure for equipment acquisition is of about Fin.Mks.13 to 14 million per year, of which over Fin.Mks.11 million as state aid

Equipment - Park	All technical and commercial institutions have computer equipment. For other institutes the situation is still far from the stated objectives of the reform
Curriculum - Computer Science	Starting in 1982-83, 15 institutions, other than technical or commercial, are to test the basic course in informatics. The trial ends in 1985-86
Teacher Training	In-service training on computers is available in technical and vocational schools and is in practice compulsory to all teachers. A development plan for both initial and in-service training is being formulated by the project group on information technology appointed by the National Board of Vocational Education

GREECE (EC, 1983)

Current Situation

In Greece, as in other countries, the NIT are heavily penetrating all spheres of life. The Greek educational system, unlike other OECD countries is well behind meeting the emerging educational needs. So far approaches are been developed to meet only the most obvious and urgent demand: that for specialists.

Until they were shut down (recently) by a Government decision, private institutions would provide such training. Additionally, and still running, training is provided by manufacturers and a state agency, the Productivity Centre, with this last providing a two-year course for young people having completed their secondary education.

More recently courses have been organised for the young unemployed graduate with financial assistance from the EEC. These are three months courses involving 200 hours of theory and as many of work in a firm.

Lower Secondary Education

Curriculum - Computer Appreciation	A few general lessons on data processing (what it is, the role it can play in daily life) are scheduled for the physics classes in Grade 9. Given the absence of computer equipment, these lessons remain theoretical. It is not certain that these lessons are actually given

Upper Secondary Education

Nothing exists in general schools.

In vocational educational establishments data processing is included in certain courses.

JAPAN

Background Information

1969 The "Proposal for Promoting Instruction in Information Processing" is issued. It will play a major role in introducing the NIT in the upper secondary schools, starting with the industrial and commercial education

The report stresses the importance of instruction in the NIT to achieve social and economical progress in the country. To achieve this broad objective the report focusses primarily on action at the upper secondary level and proposes simultaneus developments of equipment and teacher training. It also recommends the creation of "Information Processing Instructional Centers"

1970 The "Course of Study for the Upper Secondary Schools" is issued by the Vocational Education Division of the Ministry of Education. Funds issued by the National Treasury under the Law for Promotion of Vocational Education allows the equipment of a number of schools

Three months training seminars for teachers and other educational staff were started in Tokyo and Osaka. Total participants numbered 60

1973 A total of 150 participants attended the training seminars. Both attendance and provisions have since declined. At present such training seminars exist only in Tokyo for only about 60 participants a year

1978 The "Course of Study for the Upper Secondary Schools" is updated. Nearly all the industrial and commercial upper secondary schools have since incorporated instructional programmes as outlined in it

The Ministry revised "Standards for Provision of Instructional Aids and Equipment" which had been enforced since 1967. The new standards defined, as instructional aids and equipment generally to be furnished, 367 items for elementary schools and 312 items for lower secondary schools, such as OHP and other audio-visual aids, maps, musical instruments, wood-working instruments, etc. On the basis of this standard the Ministry drew up the "Second 10-year Plan for Provision of Instructional Aids and Equipment to Compulsory Education Schools", to be started in 1978 with a total budget of Y 230 billion (this is a subsidy by the National Government for the expense of the Plan, which is a half of the necessary amount. The rest is to be paid by local governments). Some instructional ads and equipment for mathematics such as electronic desk calculators are also furnished.

Current Situation

A major technical problem for NIT in education relates to the Japanese alphabet, which makes the interactive use of the NIT difficult. Another serious problem is the self-innovative movement in education as well as the teachers themselves, showing great caution with educational experimentation in the normal class. There is little corelation between classroom teaching and educational research activities.

Another major obstacle is teacher training provisions, which, chronically indequate in the past, can perform only less well for the NIT.

Primary and Lower Secondary Education

Equipment - Park	As from January 1983, only 0.1 per cent of the public primary schools were equipped with an average of 1.1 micro-computer per school. The figures for the private schools were of 5.4 per cent and 2.4 respectively. The situation of lower secondary schools was only slightly better. Only 0.9 per cent of the public and 18.2 per cent of the private schools were equipped with an average of. respectively, 1.3 and 3.1 micro-computers per school. It is felt that these figures will increase very rapidly, starting with the private schools (the privately run normal "day" schools as well as the "juku" - the privately organised evening and weekend schools)
Equipment - Financing	Equipment financed by the Ministry of Education and local (prefectural and municipal) governments
Target Group	So far, mainly the underachievers
Curriculum - Computer Science	No plans exist for introducing computer science at the primary level, although some trial programmes are being introduced in mathematics classes. All pupils have of course such aids as electronic calculators.
Curriculum - Computer Appreciation	No plans exist for introducing computer appreciation at the primary level. Pupils are however taking one-day social study field trips three to five times a year. In the cities and towns, children can easily access the electric goods like microcomputers, electric calculators, etc. in the shops as well as computing centres.
Software - Subject Areas	Computers used mainly for drill and practice in mathematics and science
Software - Production	Mainly the local school and university teachers
Software - Diffusion	There is still no system for nationwide documentation which has taken ease of management and transferability into consideration

Upper Secondary Education

Computer-related developments have taken place mostly in vocational (industrial and commercial) schools. Academic schools have been only scarcely affected.

Audio-visual equipment is on the contrary diffused in all schools.

Equipment - Park	As for January 1983, 49.8 per cent of the public and 32.2 per cent of the private upper secondary schools had computer equipment, with an average of 3.9 and 4.8 micro-computers per school, respectively. The percentage of schools with more than 10 micro-computers was of 7.5 per cent in the public and 13.9 per cent in the private sector.
Curriculum - Computer Science	Computers used mainly for understanding the computer as well as scientific concepts
Software - Diffusion	Experiences and ideas are exchanged within and between the two large teacher associations: the "Japan Society for Research in Information Science Instruction" (industrial schools) and the "Japan Society for Research in Information Processing Instruction" (commercial schools)

Trends for the Future

General Trend

Generally speaking, education in Japan is changing from only teachers being the users of teaching materials and equipment towards objective use by the students themselves.

A comprehensive database on instructional objectives, instructional materials and items for student evaluation is being developed at the Gifu University and the Kyoto University of Education. Future teachers will have to have the skills and competency to be able to use file systems of this type in instructional design.

As to the development of courseware, progress is expected from two kinds of development: the cooperation between private sectors and research institutes and the development of authoring systems or softwared needing no programming. The latter, based on the findings from artificial intelligence research and knowledge engineering should provide a solution to the problem of the Japanese alphabet.

As to specific CAI courseware, both drill and practice and simulation, Japanese made micro-computers offer almost full functions for producing them effectively. Teaching materials in this area are expected to multiply.

In addition to these researches, in institutes as well as in the private sector, the Ministry has started consultation meetings since September 1983, on the functions of the new media in education.

NORWAY

Background Information

In Norway experiments in the field of computer education at the lower secondary level (grades 7-9) were launched for the first time at the beginning of the 70's. In the upper secondary school (grades 10-12) experiments had started a little bit earlier. The teaching of computer science is now being introduced in various branches of upper secondary education, and priority has so far been given to developing courses within commercial education.

In January 1984, a White Paper on information technology in schools has been submitted to the National Assembly by the Ministry of Church and Education.

This parliamentary report includes a policy programme for the next years, with a view to strengthening further research & development work in this field.

This Ministry has laid down a proposal to standard requirements for data equipment to be used in primary and secondary education. On this background suppliers have been invited to compete for orders on equipment likely to be used as a part of further research & development work within primary and secondary education.

Current Situation

Equipment - Park	Statistics are not available on the number of primary schools (grades 1-6) with data equipment. However, as primary and lower secondary education in some cases are given in combined schools, some primary schools will have access to data equipment, usually present in the latter.
Equipment - Financing	The equipment is financed by the owner, e.g. the municipality
Curriculum - Computer Science	The teaching of computer science is not compulsory at the primary level. However, on the initiative of a limited number of teachers computers are occasionally used in some primary schools
Curriculum - Computer Appreciation	Not compulsory

Lower Secondary Education

Equipment - Park	Approximately 200 out of 1100 schools have got equipment
Equipment - Financing	The equipment is financed by owner, e.g. the municipality

Target group	Pupils of all abilities
Curriculum - Computer Science	Computer science is offered as an optional subject 2 lessons per week in the 8th or 9th grades at approx. 200 out of 1100 schools. At some of these schools, priority is given mainly to programming, whereas other schools ar also studying the possibilities for making use of computers, and the role of computer technologie for the individual and for society as a whole. The Basic School Council is at the moment preparing a draft framework plan for the teaching of computer science as a compulsory topic within other subjects such as mathematics, natural science, Norwegian and civics.
Curriculum - Computer Appreciation	See above
Software - Production	No system has so far been organized for national distribution of soft-ware. However, in the South-Eastern districts of the country a number of municipalities have been co-operating within the framework of the so-called DAISY project. This project is among other things aimed at developing and the distributing software within the participating municipalities.
Teacher training	No systematic training is available for teachers already in service - Voluntary in-service courses are organized, and teachers already employed are free to apply for admission to such courses. Eight colleges of education are providing 1/2-year courses aiming at primary and secondary education. These courses may be taken either as a part of the initial teacher training or as continued training. A limited number of teachers have been studying data processing at universities and regional colleges, but these courses are not especially intended for teachers. Many teachers also attend voluntary evening courses in data processing at private educational institutions

Upper Secondary Education
(general education)

Equipment - Park	A majority of the schools have got equipment. They are free to choose their own equipment,

	and for this reason it exists a variety of different types of computers.
Equipment - Financing	The equipment is financed by the owner, e.g. the county
Curriculum - Computer Science	Optional subject 2 lessons per week for one year's duration. The curriculum includes the use of a computer as well as programming and the impact of data technologies on the individual and on society as a whole. About 60 per cent of the schools are offering computer science as an optional subject. At some schools the students may even take advanced courses 3 lessons per week in a second year.
Curriculum - Computer Appreciation	Besides the instruction integrated in the computer science courses mentioned above, some schools offer a specific and compulsory course (10 lessons in a year)
Software - Production	See: lower secondary education
Teacher Training	A majority of the teachers in charge of the optional courses (2 lessons per week) have got less than a 1/2-year training programme within this field. No systematic in-service is offered for those already employed. Eight colleges of education are offering 1/2-year courses, which may be taken either as a part of the initial training and are as continued training. Some teachers have been studying data processing at universities and regional colleges. Many teachers also attend voluntary evening courses organized by private educational institutions

Vocational Education

Equipment - Park	All upper secondary schools offering commercial and clerical subjects have got equipment. Equipment is also to be found in a number of schools offering vocational education in handcraft and industry
Equipment - Financing	The equipment is financed by the owner of the school, e.g. the county, with state subsidies ranging from 35 to 75 per cent of the actual costs. In some cases the equipment is paid completely by the state, especially when it comes to high cost investments in schools which have been selected to serve as centres of knowledge in this field.

Curriculum - Computer Science

For commercial and clerical lines the course has a compulsory and an optional part distibuted differently over the three years. The heaviest curriculum load is in the branch for "computer and information processing" where the course is of 38 weeks' duration with 15 lessons per week. Data processing and computer science is to an increasing extent being introduced in vocational trades, for instance by means of numerical control of workshop machinery, microprocessor applications within the electric trades and automatic welding equipment. Within the book trade data processing has been introduced on a large scale. A specific optional course in computer science (2 lessons per week, 1 year's duration) has been developed for pupils within the vocational areas of study.

Curriculum - Computer Appreciation

Besides the instruction integrated in the computer science, some schools offer a specific and compulsory course (10 lessons in a year)

Teacher Training

As far as vocational teachers are concerned, it has been considered to be of special importance to raise the general level of knowledge within computer science.

Combined training programmes organized by private correspondance courses have been recognized as a basic training. One of the central tasks for the centre of knowledge to be established will be to organize continued and in-service training for teachers within the respective regions.

The State Institute of Technology has, in co-operation with industry and vocational schools, prepared course programmes in the field of numerical control. Similar course programmes are also being prepared for the book trade.

The State College of Vocational Education is actually preparing an extensive course programme for teachers in the field of general computer knowledge.

PORTUGAL

Current Situation

Primary Education

The state schools are not involved, for the time being. It is not impossible that the NIT be introduced in the near future in experimental settings. As for audio-visual techniques, the "preparatory classes" (children aged ten to twelve) have been using four hours of daily broadcast of an Educational Television Network for more than a decade (TELESCOLA)

Secondary Education

No large scale introduction of the NIT has taken place in secondary schools. However, a two year experimental programme is being carried out by the Univerity of Porto aiming at introducing computer assisted instruction in two to four secondary schools, in Grades 10, 11 and 12. The planned equipment investment is of US $60,065 per year for a number of computer configurations large enough to allow seven hours a week of interaction to groups of three pupils each.

Curriculum - Computer Science	Informatics is one of the optional vocational subjects in secondary education. The course, lasting for a school year, has been introduced at Grade 12 (classe terminale) in about 10 per cent of the schools
Curriculum - Computer Appreciation	No separate courses exist. The subject matter is discussed in the economics classes and could in future be part of the Social Studies curriculum
Teacher Training	No training provision in computers exists

SPAIN

Background information

1960s	The NIT are introduced first in higher education establishments
1968	"Permanent" programmes in the NIT are introduced as part of the Faculties of Science programme
1969	The Institute of Informatics is created autonomously within the Ministry of Education and Science
1970	Experiments on the introduction of the NIT in schools are started on a voluntary basis and in a scattered fashion throughout the country. The trend will continue for the whole decade without central control or evaluation
1976	On the basis of its seven years experience, the Institute of Informatics is integrated in the Vocational Education and Higher Education Sections of the Ministry
1978	Following a recommendation of an international conference on "Strategies and Policies in Informatics" held under UNESCO patronage, the Spanish Government decides to develop a national plan to introduce informatics at all levels of education
1980	The new Spanish Constitution is introduced
1981-83	The primary and lower secondary levels of education are "renewed"

Current situation

1983 - Informatics introduced in the mathematic curriculum of the 8th year of schooling

- The scattered experiments carried out since the early 70s are evaluated in view of identifying the expert teachers and designing national teacher training courses

- The idea is launched by the competent authorities that educational specific hardware should be produced which could be manufactured by the national electronics industry

SWITZERLAND

Background information

1973 One of the universities (Neuchatel) launches a study on the introduction of the NIT in education. The resulting "expert" report (the Banderet report) is published by the CPS, the "Centre pour le perfectionnement des professeurs de l'enseignement secondaire"

1975 The Banderet report is discussed at a conference of CPS. An outcome of the conference is to organise an ad hoc group of teachers (secondary and higher education) charged to draft a report to be submitted to the highest education authorities in the Cantons: the Cantonal Heads of Departments of Education.

1978 The main recommendation in the report, that a minimum course of 24 hours be introduced compulsorily in all types of "maturité". The objective of the recommendation is twofold: to give a body of knowledge to the pupils as part of their general education, and to develop the use of the NIT as a pedagogical aid in all disciplines. The report takes a stand as to the optimum age of the learner: the pupils in their 10th year of schooling

Current Situation

The Swiss situation is one of widespread experimentation in upper secondary education.

1978-83 Of the 124 schools delivering the "baccalauréat" recognised by the Confederation, 72 per cent offer a course in informatics. Similar courses are given in an additional 22 upper secondary schools not sanctioned by such a recognised diploma. An estimated total of 12.5 per cent of the school population in "baccalauréat" and commercial schools receive a basic education in informatics. For about half of these pupils the courses are compulsory (one session a week for forty weeks). In commercial schools the frequency of lessons is higher (three sessions a week for a total of 120 lessons in a year). In these courses informatics is used most often as a teaching tool in disciplines such as mathematics, physics, biology and economics.

TURKEY

Current situation

The NIT was introduced first in the higher education establishments in the 1960s. Introduction of permanent programmes in NIT was started at the master's degree in 1967, at Bachelor Degree in 1977, by Middle East Technical University which was followed by Hacettepe University, Ege University, Bosphorous University and Yildiz University.

As yet, the school system has seen very little of the NIT. No policy exists as to the introduction of NIT in primary education (covering both primary and middle-level schools) while a development plan is underway to introduce computer science training more widely in vocational and technical educational sectors. The equipment of secondary schools is also expected to increase.

Secondary Education

Equipment - Park	One technical high-school has a modest computer equipment
Equipment - Financing	Equipments are financed by the Ministry of National Education
Target Group	All pupils
Curriculum - Computer Science	Computer Science programmes are prepared by the Central Organization of the Ministry of National Education in cooperation with the related universities. Computer Science courses are optional. A two hours a week course is available in two high-schools where some subjects are taught in English Language. Computer Science programmes are also given in years 10, 11 and 12 in a stream named "Computer Science" opened in one technical and one vocational school. These courses last for 36 weeks (one school year).
Software	A severe shortage of software exists. What is available comes from both universities and commercial producers. Its financing as well as diffusion is assured by the related universities and the Ministry of National Education. The quality control for the software is done by the university.
Teacher Training	Teachers are trained by the universities mentioned above.

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HIGHER EDUCATION AND NEW INFORMATION TECHNOLOGIES: TRENDS AND ISSUES

1. The attached document has been prepared by Pamela Christoffel, United States, in her capacity as consultant to the Secretariat. It will serve as a background report for the Plenary session on Theme 1 and Working Group 1 and 3.

2. The views expressed are those of the author and do not commit either the Organisation or the national authorities concerned.

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INTRODUCTION

A. Study Background

1. As part of the preparations for the Conference, the OECD Secretariat distributed a questionnaire to member countries. The survey (CERI/NT/82.01), mailed in May 1982, sought information concerning the introduction of new information technologies (NIT) in each OECD Member country. The country enquiry did not define NIT, but implied a broad definition by including questions about computer-assisted and computer-managed instruction, computer science training, software, and educational uses of telecommunications. The survey focused on the primary and secondary education levels, with the higher education and adult learning portions being optional for respondents. Nevertheless, some countries (1) provided at least a brief response to the higher education section of the survey. These higher education responses from Member countries serve as a starting point for this issue paper.

2. In addition, a number of available secondary sources describing recent higher education and NIT developments in the various countries have been used in preparing this report. Unfortunately, the total amount of available data and information in the higher education sector is not great. This paper, therefore, is not a comprehensive survey of the field, but instead should be considered a brief overview of trends and issues. Its purpose is to begin a dialogue among Member countries on the subject of higher education and the NIT.

3. This report is divided into two main parts. The first (TRENDS OBSERVED) outlines some of the current developments - at the national level in terms of planning and other initiatives, and at the institutional level in terms of utilization of the NIT. Within institutions of higher education, this study examines possible changes in educational mission, functions, educational "courseware", research and the role of faculty.

4. The second part of this report (ISSUES FOR THE FUTURE) addresses some of the questions which will confront policymakers and educators in the decade ahead concerning the NIT and higher education.

5. Before moving to the first major section of this report,

however, it is worthwhile to consider briefly the context in which systems of higher education operate in OECD Member countries today.

B. The Broader Context

6. Over the past decade OECD Member countries have faced a period of economic troubles which have caused high unemployment, financial pressures and significant restrictions in governmental budgets. Older industrial bases have eroded. Foreign competition is strong in a world where international commerce is commonplace. Attempts to foster international economic cooperation to help offset these ills have met with only limited success.

7. At the same time, Member countries are passing through an extraordinary period of rapid technological development and change. Countries are anxious to modernize their economies, increase employment by creating new jobs, train new professionals and technicians and revitalize their financial situation in the face of what the French Prime Minister has called the "third industrial revolution." Computers and other elements of the NIT such as advanced communication systems (cable, microwave, interactive videotex, etc.) are an important part of this new revolution.

8. The situation facing higher education institutions in OECD Member countries is also troubled. In part this state of affairs is due to the broader economic context, and in part it is due to other, separate factors. Described simply, the factors affecting postsecondary education in the developed countries include:

i) actual or expected declining enrollments which are spurring efforts to attract 'new' students such as adults;
ii) increasing operational costs coming at a time of decreasing public support;
iii) new demands from students for more specific vocational programs, such as engineering, computer science, and other professional studies;
iv) rising pressure from governments at various levels to educate for specific (growing) employment sectors; and
v) greater expectations that the higher education system's capability to support economic and technological progress must be improved.

9. Higher education institutions are often regarded as "public utilities" in many Western European countries. Governmental interest and scrutiny is keen, there and in other OECD Member countries, as universities are reviewed as to their capabilities to help countries out of tough economic conditions. At the same time, enrollment situations are changing, the difference being described as higher education institutions moving from a condition of "apoplexy" to one of "anemia."(2) Educational costs for facilities and maintenance, for

faculty, and for new educational equipment are rising. Yet a recent headline in the International Times Herald reads "West Europe Making New Cuts in Social Programs"(3) with education funding included in these reductions. The situation is similar in the United States, the United Kingdom, and elsewhere.

10. In addition to these problems, students and others continue to criticize higher educational institutions for being out of touch with the world of work, offering programs and courses not well related to necessary job skills and positions. Recent high unemployment levels have sharpened student concerns here. Increasing numbers of students are 'voting with their feet' at colleges and universities, swelling enrollments in such practical educational programs as engineering and computer science, where jobs upon graduation appear more likely and disregarding such programs as humanities and arts.

11. Yet business and industry in many OECD countries remain dissatisfied with higher education's 'outputs.' In Italy, for example, engineering companies have become so disenchanted with the quality of engineering students coming from engineering schools that they have set up their own evaluation system.(4) In the United States several large corporations have set up their own colleges, accredited to give degrees, in order to train employees better. In many Member countries colleges and universities can not prepare graduates in certain fields fast enough to meet the immediate needs of industry.

12. The impact of these complicated and harsh realities for higher education - particularly relating to such problems as access, changing relationships between higher education, communities and working life, patterns of authority and financing issues - are discussed in depth in the recent OECD publications, Policies for Higher Education in the 1980's and The University and the Community: The Problems of Changing Relationships(5). The problems need not be repeated here. Suffice it to say that the presently troubled context for higher education in most developed countries should be considered as essential background to the topic of this paper: the impact on higher education of NIT. External and internal pressures on the higher education 'enterprise' are an integral part of the problems and potential outlined in this brief analysis.

13. Both policy-makers and college and university officials are asking questions like the following. As we move into the "Information Age," will higher education be able to contribute to the pace of technological and scientific advancement in OECD Member countries? Will the education about and use of NIT in higher education help students in their preparation for work? Will colleges and universities be able to prepare and train the new cadre of professionals and others needed to staff the "third industrial revolution"? Can the use of NIT help institutions attract new students to offset declining enrollments? Will their use enable schools to teach and educate more effectively? What are the costs and benefits?

14. Even the most fervent enthusiast for the potential of the NIT will agree they represent no panacea for higher education - no easy answers to the external and internal pressures facing colleges and universities today. But can they help? What are the current trends toward implementation of the NIT in higher education? What issues remain unsolved? A broad study of the inter-relationships among governments, industry and higher education in the area of NIT development is clearly beyond the scope of this effort. Instead, this brief analysis seeks to describe current trends in the various countries and goes on to point out some of the major issues regarding the use of NIT which will continue to confront us in the next decade.

Section I

TRENDS OBSERVED

15. Detailed information and accurate data about the use and impact of NIT is in short supply. But from country responses to the OECD survey in this field and a variety of secondary sources, the following picture can be drawn.

16. In terms of governmental planning, a significant number of countries have begun developing public policies, with some also providing support for programs or equipment.

17. Within colleges and universities themselves can be seen trends toward an expanding educational mission - for professional education, for more general education and for educational outreach via distance learning. New educational functions are emerging, using computer-assisted instruction (CAI) and computer-managed instruction (CMI). The search is on for new educational materials to be delivered using information technologies - the problem of finding or developing quality software. Research missions are being redefined in many higher education institutions as the NIT are made more available on campus. And the heart of colleges and universities, the faculty, are struggling to identify their role in the utilization of these new learning tools.

18. And what has been the influence of industry in all of this activity?

19. All the above factors are having at least some significant impact on higher education, varying of course in each individual country. These policy developments and trends within higher education institutions themselves are described in some detail in the next sections.

A. Public Policy Developments

20. Across OECD Member countries, the general economic problems and increased pressures on the higher education system have led to a great diversity of response. This situation is also true with respect to the particular issue of NIT. In fact, it has been noted that "national policies, to the extent that they exist, are essentially concerned with lower levels of education, and exceptionally only with the university (or other higher education institutions)."(6) However, some countries (France, England, Scotland, the Netherlands) have done a significant amount of planning for the integration of NIT into their higher education systems. The impetus here has largely come from economic and new manpower development pressures, though there is also a desire, especially in France, to improve the education system as well.

21. Existing national policies do not generally assign special responsibilities to institutions of higher education in the policy implementation process, or in the development of informatics throughout the educational system. France is a major exception here. In France, the Ministry of Education's "plan de developpement informatique" was developed out of a major study begun in July, 1981. This "Mission of enquiry on informatics in the school" resulted in a report to the Minister of Education titled "L'introduction de l'informatique dans l'Education Nationale," also known as the Pair/LeCorre report.(7) The new policy had three main objectives: first, to give information technology a place in general education; second, to use information technology to make teaching more effective; and third, to educate future specialists in informatics and professionals who will be needed.(8) Higher education is expected to play an "essential role" in the development of these new French policies.

22. In contrast, there has been little national planning regarding higher education and NIT in such countries as Germany, the United States and Canada. Clearly this is due in large part due to the federal structure of these countries and the traditionally small role played by their national governments in the development and functioning of their higher education systems. In the United States, for example, the federal government has done virtually no planning for implementation of the NIT into the higher education sector.(9) Some planning activities have been undertaken at the State level, through the State Higher Education Executive Offices in particular states. But in most cases planning has been left to individual colleges and universities, with major initiatives also coming from business and industry.

23. National planning activities in other OECD Member countries, notably Japan, Ireland, Finland, Belgium and others fall somewhere in between in range of effort. The impetus in these countries is usually

a mixture of forces - economic, manpower needs, desires for regional development and, to a limited extent, plans to improve the educational system as a whole. Most have developed at least some plans or established national committees and advisory groups to consider the problem and make recommendations to their governments for future development.(10)

24. In Japan, for example, an advisory committee to the Ministry of Education, Science and Culture (Monbu-Sho) has recently been asked to study and report on the following questions:

i) How can the new technologies, especially information and communication technologies, be utilized?
ii) How can educational information network systems be developed? and
iii) How should the problem of media literacy (including computer literacy) be dealt with?

25. The committee is scheduled to submit a report on computers by June 1984.

26. Several study and working groups have been appointed by the Finnish Ministry of Education. One has been examining the potential of computer-assisted instruction in higher education. Another considered the use of computers in university-level education. The Ministry also prepared a plan recently concerning the development of automated data processing (ADP) training in higher education.

27. In Ireland, the Higher Education Authority's Advisory Group on Computer Services has recommended the formulation of a five year plan for computer development and the establishment of integrated systems and networking between colleges.

28. These are just a few examples of the various kinds of national planning activities undertaken within the last few years in OECD Member countries. The overall situation is in a state of flux, with national policies constantly being developed and adapted.

29. In some cases the planning efforts have been followed by actual funding for equipment or programs. As would be expected, this has generally occurred in member countries with strong policy development efforts. In the United Kingdom with its generally decentralized higher education system, the autonomous universities are funded through central government which channels monies to the University Grants Commission (UGC) for distribution to individual universities. Planning groups in the area of educational technology have been active for years here. At the end of 1982 the British government announced a 100 million pound three year programme for boosting information technology. The effort called for an additional 2,000 students in 1983 in universities, polytechnics and other colleges, building up to over 5,000 in 1985-86. It also included a significant increase in provision in non-advanced further education, and a large new programme of

research grants and fellowships. Sixteen polytechnics and colleges were chosen for a two million pound funding program for information technology courses.(11)

30. In France, 139.7 million francs were budgeted in 1983 at the university level, up 59% from the previous year's spending, and efforts are currently underway to increase the numbers of students earning diplomas in informatics. Fifteen university centers are also being established to train teachers, and other higher education projects are being implemented as well.

31. It should not be assumed that in these various countries, national-level planning is carried out neatly and logically prior to actual provision of monies. In reality, planning is often carried out at the same time individual (sometimes uncoordinated) projects are being funded. Few governments are so organized that they are able to carry out detailed and comprehensive planning for implementation of NIT before acquiesing to demands for funding of particular projects or equipment purchases at individual institutions. The result is somewhat haphazard and uncoordinated development, with planning activities in some cases trying to rationalize and account for already ongoing activities or programs.

32. Still, renewed efforts to conduct national NIT planning has been carried out in many OECD countries, particularly in Europe, as governments move as quickly as possible to catch up with events. They are being pressured into action by concern that rapidly developing technology, bringing new business and new jobs, may pass them by and be attracted to other, more competitive nations which have been willing to plan for and invest in the NIT. Indeed the broader problem of economic development in this period of high technology growth is the real spur to government action here. Even countries with no significant national planning efforts underway have made a choice. As at least one expert has pointed out, "Deliberate absence of policy is itself a policy."(12)

33. The current United States view is that, given the right economic conditions, private enterprise, including the higher education system, will work perfectly well if left free of national government intervention in the development of NIT. Other countries have opted for a more mixed approach, with some planning and varying amounts of government funding and incentives. Their major focus may be on secondary education, but higher education planning is becoming increasingly evident.

34. National planning efforts will be discussed further in the next sections as an examination is made of trends in higher education institutions themselves.

B. Trends in Higher Education Institutions

35. In an era of retrenchment for higher education, the introduction of NIT in colleges and universities must be considered a bright spot, generating not a little excitement and optimism. New equipment, new courses, new students, new interest - all combine to quicken the tempo of activity at many higher education institutions. Whether the impetus has come from government or from within the institution itself, the impact of the introduction of the NIT has been felt in a number of areas. (It should be noted here that trends in teacher training, a task of higher education institutions, are not addressed in this paper. Instead, they are covered in the OECD paper, "The Introduction of New Information Technologies in Education: Policy Trends and Developments in Member Countries" (CERI/NT/84/02).

1. Expanding Education Mission

36. In professional education, in general education through the liberal arts, and in distance learning, institutions of higher education have begun to expand their education mission. This process is occurring across most OECD Member countries - sometimes slowly in only a few colleges or universities, but elsewhere in a large number of institutions.

37. In professional education there has been substantial growth, not only in the particular field of computer science but in other professional fields as well. This growth is evident in most Member countries, and it is clear that it is in this area of professional education that the NIT have had their greatest impact on institutions of higher education. In Japan for example, the number of computer science departments grew from five in 1970 to 43 in national and private municipal universities by 1980. Computer science is now being taught in all the technological universities in Turkey, and all engineering students as well as some from other disciplines, receive obligatory training in computer science.

38. In Ireland there were 29 specialised courses in the computer science area available at seven third level colleges in 1981. That same year about 5,000 students took modules in computer science at Irish institutions as part of their overall training in other areas, mainly science, engineering and commerce. The University of Linkoping in Sweden has a special "Computer science and technology line" where computer science is the main part of the education - one of several lines leading to a "Master of engineering science." This program is unique in Sweden.

39. Another good example of the rapid growth and restructuring of professional education is in Scotland where computing modules are included in Higher Diploma and degree courses wherever relevant (some voluntary, some not). Thus, report Scottish authorities, all engineering students would have a course in computing, and many science and business studies students would have similar courses. They

also report that the numbers of students taking computing modules and full computing courses have increased rapidly in the last five years. The total intake has probably doubled in the last three years and the demand for places in degree courses (both in colleges and universities) is such that the entry qualifications are steadily rising. Indeed, in Scottish universities the entry qualifications for computing and for microelectronics courses are starting to rival those of medicine and law.

40. In the United States where 90% of all colleges and universities either have their own computers or access to others, all types of institutions, public and private, two-year and four-year, offer courses and degrees in computer science. Enrollments are growing due to demand from business and industry for such students. Computer courses are also a standard part of the curriculum in such fields of study as statistics, the physical sciences and engineering. NIT are also used extensively in American colleges and universities to deliver professional continuing education. A recent survey (13) found their use in such programs as allied health, medicine, engineering and high technology, business, education, law and real estate.

41. In fact, the United States also has a number of good examples of the use of NIT other than computers for professional education. One of these is an association of 17 universities in the Dallas-Fort Worth, Texas area, the Association for Higher Education of North Texas. The Association operates the TAGER Television network, the largest closed-circuit higher education network in the U.S. It offers courses, 85 percent of which are graduate-level engineering, business, and computer science courses for credit. TAGER has developed a hybrid distribution system using ITFS broadcast, point-to-point microwave, cable, satellite, videocasette and telephone and has a unique organizational structure that shares governing powers between the local communities (two-thirds) and the higher education institutions participating in the program (one-third). The TAGER Network combines complex technology and low-cost video production to serve highly motivated learners in professional fields.(14)

42. In general education, the use of NIT has not been so widespread in the various OECD Member countries. Colleges and universities have concentrated their efforts initially - for equipment, for faculty and the development of new courses - in the revision of their professional education programs. Nevertheless, a number of countries report the use of NIT for education of non-specialists.

43. In Finland the Ministry of Education states that computer science is a compulsory subject at the stage of general studies (first year) for students in mathematics, natural sciences, and economics, and at the stage of advanced studies for students in social sciences, education sciences and physical education. In Britain the UGC has recommended that all undergraduates should have some education in the use of computers, report authorities there, since the UGC "feels that the spread of computers into everyday life needs to be accompanied by

an understanding of what they can and cannot do and by an assessment of social problems arising from their use."

44. Some universities in Japan have computer centers specifically installed for educational utilization, and the teaching of computer utilization skills to non-specialists is rather widespread. In the United States a number of colleges and universities have gone as far as requiring all their entering students, regardless of field of study, to purchase microcomputers, with the cost (discounted) usually being included in the tuition charges. The expectation at these schools, which are mostly private universities, is that the students will use their micros for at least part of their work in all their subjects.

45. Beyond computers, higher education institutions in America use other NIT in liberal arts curriculums. For example, Rio Salado Community College (Phoenix, Arizona) has no campus but offers classroom courses in lower division general education and liberal arts as well as occupational programs to over 2,000 students a year. The school uses public and commercial television, cable television, its own public broadcasting radio station, audio teleconferencing, slow scan television, video and audio cassettes and telephone to serve its students. And one of the United States' most futuristic programs is at Columbus (Ohio) Technical Institute where undergraduate liberal arts courses are offered using live, interactive cable television together with videotape. The system is called QUBE, and during the interactive sessions students viewing the television course can respond to questions posed by faculty by pushing buttons on a hand-held keypad device. Student responses are relayed to a computer in the television studio which summarizes responses for faculty immediately.(15) While extremely innovative, the QUBE experiment in Ohio has not yet been duplicated widely elsewhere in the U.S.

46. Expansion of educational mission through use of the NIT is perhaps most visible in OECD Member countries where distance learning institutions have been established. Following the lead of the British Open University, a significant number of countries have agreed that educational outreach is a new but important mission for their higher education system. While substantial numbers of students are not yet involved, the NIT play an important role in these types of institutions.

47. In Germany at the Fernuniversitat, in Finland, in Norway through the Norsk fjernundervisning, in Canada, in Australia at Deakin University, in the United States, in Japan with its forthcoming Broadcast University of the Air and in the Netherlands where the new Open University is expected to open this year - all these universities use a variety of NIT to reach students.(16) Many of these students are adults, working or homebound who would not otherwise be able to participate in higher education. Two of these distance learning institutions are worth describing in some detail.

48. The Fernuniversitat in Hagen, West Germany opened in 1975 and enrolls some 23,000 students, both full time and half time. Like all the other universities in Germany, it is a State university and is made up of faculties in Educational and Social Sciences, Economics and Business Administration, Mathematics and Computer Science, Law, and Electrical Engineering. The course and examination structure corresponds to that of conventional universities in West Germany. The predominate teaching medium remains printed or written materials, but audio cassettes and televised courses are also used. In regional study centers students can also use specially developed recordings and video tapes, and the university has recently begun a videotex experiment.(17)

49. On the other side of the world is Deakin University in Geelong (Victoria) Australia. Officially opened in 1977, Deakin serves on-campus students as a regional university as well as off-campus students (who number about 3,500), approximately 60% of the university's student population. Deakin uses microcomputers, telephones and satellites in innovative ways to serve students off-campus and to manage their instruction.(18)

50. While still not numerous relative to the total number of colleges and universities (and unlikely ever to become so) the distance learning institutions nevertheless represent a significant departure, serving students (mainly adults) off-campus in new and innovative ways. Their emergence is due at least in part to the availability of the NIT which permit new modes and methods of off-campus learning. Their existence in many European countries and their utilization of the NIT capable of reaching across country boundaries has prompted at least one expert to suggest establishing a commission to study the formation of a European Open University Network, noting that "the difficult economic situation in which virtually all Western European countries now find themselves, requires greater efficiency and collaboration in the domain of education."(19) He suggests that such a flexible structure of cooperation will be needed in the next decade as technological developments draw the various members of the European community closer together. Of course differences of language and higher education systems must also be addressed. Networks are discussed further later in this paper.

2. Developing New Educational Functions

51. NIT have potential to change the very nature of the educational instruction process as well as the methods used to "manage" or administer the instructional system. When computers are used as the tool, these new functions have been labeled, respectively, "computer-assisted instruction (CAI)" and "computer-managed instruction (CMI)." The word "potential" is used quite deliberately here, because available research has largely been able only to hint about the usefulness and quality of CAI and CMI. Neither is reported in wide use as yet among institutions in OECD Member countries. Whether or not either will be adopted to a greater extent over the

next decade is presently a matter of speculation - dependent on such variables as cost, perceived quality, and effectiveness.

52. Regarding CAI, the Netherlands provides a good example. According to one report (20), CAI (as well as CMI) is used in more than thirty courses at 12 of the 14 universities in the Netherlands with about 6,000 students participating. According to this study, "An initiative of five universities to purchase a dedicated CAI-system and operate this in cooperation has not (yet) succeeded..." due to various institutional and government budget restrictions. Present CAI efforts have been assessed, in terms of quality as falling "very far short of its potential." Cost comparisons included in this Dutch study of CAI versus traditional instruction show CAI costs per student contact hour to be substantially more than costs of traditional instruction unless relatively large groups of students participate.(21)

53. Elsewhere, a number of countries (Belgium, Luxembourg, Sweden, Finland as well as the Netherlands) have experimented with an American CAI system - PLATO - developed by Control Data Corporation in conjunction with the University of Illinois. These experiments have been generally limited and short-term in nature with little widespread impact or priority. PLATO continues to be used as a CAI system (with substantial amounts of higher education courseware available) at a number of United States colleges and universities.

54. More extensive use of CAI is reported in Great Britain where "impressionistic evidence confirms CAI is becoming more widespread in higher education." It is used extensively in the operations of the British Open University where they see great long term educational potential because of CAI's interactive ability for individual students, its capability of patient, instant feedback, its simulation potential and its communication and database capability enabling students to access information quickly.(22) This study also notes, however, the substantial costs of CAI (not so much for hardware where costs are falling, but for educational software where production costs are rising) as well as the problem of quality ("studies demonstrate that CAL (CAI) can be used effectively to supplement existing education provision but much of the CAL that has been created has not been educationally effective at all and has been discarded.") (23)

55. In Scotland all higher education institutions are reported to have CAI equipment, and in Japan it is used extensively in the national technical colleges. Italy also reports slow progress but growing interest, especially in university-based research projects on CAI (at the Universities of Milan, Genoa, Naples, Catania and Bari). So far, however, it is evident that regardless of its potential, CAI is being viewed very cautiously in most countries and adopted slowly if at all. More research on the effective use of CAI is now underway in such places as the Institute for Computerised Learning Environments at the University of Stockholm, the Computer Assisted Learning Research Group at the British Open University, and the Computer Assisted Instruction Laboratory at the University of Paris VII.

56. Similar findings regarding extent of use apply to CMI, as well. Few countries report its extensive use in higher education institutions. Again the potential is substantial. According to an American study,(24) CMI can accomplish a great deal without requiring computer access by the student. This study notes CMI's abilities to: "present alternative goals that students select to determine their learning paths; continuously monitor and assess how much practice a student requires, how well information is retained, and what methods of study work well; use previous performance data to prescribe specific methods of study or testing; and provide the instructor with group and individual statistics to help in the revision of course materials."

57. Specific examples of CMI use do exist in Member countries. In Japan SIS-TEM III, a computer-based educational system, has been developed at Gifu University. It is designed for management of teaching and learning items, administration of student data and for all-inclusive utilization of computers in school education. (25)

58. CMI is also utilized at several of the distance learning institutions. At Fernuniversitat in Germany, computers are used to correct and grade students, and similar systems (sometimes interactive) are in operation at the British Open University. In Canada, TV Ontario has a computer-managed learning system (RSVP) which was originally developed and still is in use at an American community college (Miami-Dade Community College, Florida).

59. If and when CAI becomes more established in higher education institutions, it is probable that the use of CMI will also increase, since the two systems work well when linked together. But until that time, widespread use of CMI remains unlikely.

3. Searching for "Courseware" and Other NIT Uses

60. The lower costs for NIT hardware over the past few years have contributed to their increased use at higher education institutions in most Member countries and sent faculty and administrators on a search of educational materials to be delivered via these technologies. In the case of computers, these are usually called "software" or "courseware." Problems are being experienced across most Member countries and seem to fall into the following categories:

i) availability, including machine compability and cost of production problems;
ii) quality problems, including questions concerning choice of mechanism for which courses for which students;
iii) higher education's role in developing courseware;
iv) does the medium change the message, and how do people learn; and
v) other uses of NIT in higher education.

i) Availability

61. In terms of availability, most countries report severe shortages of (good quality) software for computers and televised programing, videotape courses, etc. for the other NIT in use at colleges and universities. In part this is due to the problem of machine compatability. In the case of computers, software developed to run on one manufacturers brand of machine will not usually work on another. Institutions of higher education investing in computers produced by one company often find themselves dependent on available software written specifically for that computer, unless some enterprising professor or student has taken the (considerable) time to rewrite the software's program so as to make it "compatible." This problem results in endless time wasted converting existing programs to run on other machines (or simply writing ten different programs to run on ten different machines).

62. The effect of all this lack of machine and software standardization is to limit severely the amount of available software. This is true whether the country's institutions rely on the open market to purchase their machines (Great Britain, the United States) or whether the national government of the country promotes the use of single, nationally-produced machines (which can't accept software written for other machines either) as in France. And since the universal truism that time means money must also apply in this case, the cost of this compatability problem is tremendous.

ii) Quality

63. Availability of software and courses using other NIT is also limited by the problem of quality. Much of what is available is simply not very good by anyone's standards. Examples exist in many Member countries of courseware tested and rejected on quality grounds. "Electronic page-turning" charges the United States Secretary of Education, with similar criticism heard often elsewhere. More subtle problems also exist. Very preliminary research suggests that the "role accorded to certain media in the teaching-learning process also depends on the educational level and other social characteristics of the target group and not merely on the subject matter and the potential of the medium itself."(26) What is quality courseware for one group of learners might not be appropriate for another group at a different educational level. This issue is just now being explored in research conducted in several countries and definitive results are not yet available.(27)

iii) Higher education's role

64. Higher education's role in the development of software, courseware, and other materials for the NIT is generally deemed to be crucial. In some countries, research organizations and centers located

at colleges and universities are working to prepare educational courseware, but in other countries individual professors at higher education institutions are the only ones working on such development. Scotland's response is fairly typical here. In terms of software creation, Scottish authorities report, "This is less organized than in the school sector, mainly because software has been written to identify closely with courses offered in individual establishments, and as these tend to vary from one college to another, so the software is tailored to meet the local needs."

65. Sometimes there are limited software exchange systems in operation among colleges and universities, but as is pointed out in the Scottish response, "the quality of the materials is very variable, ranging from small programs written for particular purposes by an individual to well documented technically sound packages...(while) some are more complex, involving interfaced equipment including interactve video tape and video disc."

66. In some other countries the role of higher education in the search for educational materials has several different aspects. In the United States, for example, while considerable amounts of courseware, televised educational programming and the like are produced by colleges and universities, a recent survey revealed some 700 private-sector firms engaged in education software development. Much of this software produced privately is directed toward the elementary and secondary education levels. Still, some is used at colleges and universities. In response a number of higher education institutions have assumed the role of courseware "evaluators," assessing the quality of this privately-produced software, occasionally with public support. Harvard University is an example here (as is the University of Edinburgh, Scotland, which has a more comprehensive evaluation contract from the Scottish Education Department).

iv) Does the medium change the message?

67. A much more limited number of institutions in Member countries (Great Britain, Canada, the United States) are seriously addressing the question "does the medium change the message" - a significant matter. How does (should) the content of a course offered via television, for example, differ from the same course offered in a standard classroom setting, if in fact it differs at all? It can be expected that, as the new technology is introduced into the learning environment, so the course content will be in some way changed or modified. A Canadian study for the OECD is a good example of work being currently done in this area.(28)

68. Interestingly, this study found that educators when addressed this question responded that "it does not or should not make any difference. In instances where instructors recognized that the 'medium' does affect the 'message' they found it difficult to specify in what ways the curriculum changes." The study goes on to conclude

"...it appears that the change of the medium of delivery does make a difference to the content of the curriculum, but that this area is not yet clearly understood. It is not necessarily that the medium affects the message, for generally the same information is transmitted regardles of medium, but that it changes the process of communication in terms of the mental skills needed to understand the message, and the relationship between the participants."

69. This introduces the deeper question of how do people learn, a topic far beyond the scope of this paper. But it is clearly a very important question just beginning to be addressed in the context of the NIT and higher education learning. Finding the answer(s) will be a complicated research process but one which must be continued as the search for educational courseware to be delivered via the NIT goes on.

v) Other uses of NIT

70. Finally, it is worthwhile to consider what other sorts of materials are being offered on higher education institutions' computers and other NIT. Three areas should be noted: provision of student counseling and advising; provision of access to broad information and data bases; and inter-institutional networking systems.

71. Beyond delivery of actual courses, colleges and universities are using the NIT to a limited extent to provide such student services as advice and counseling. Computer-assisted counseling is an interactive process where the computer is used to present information, solicit and monitor responses and select and present additional information in accordance with individual client needs. There are several American examples here. Online career information and guidance systems are sophisticated tools available to counselors to help students, and are used at a number of colleges and universities. Some which are available, such as CHOICES, CIS, COIN, and GIS, provide online information storage and retrieval where the user has interactive, structured (but non-threatening) interviews with the computer.

72. Other systems, such as DISCOVER, EXPLORE, and SIGI, deliver significant amounts of guidance content beyond career information. They provide simulation, exercises in values clarification, decision making, classification of occupations and help assess the current status of career development.(29) The PLATO system, described above, is also used in the United States to provide student guidance, notably by the city of Baltimore, Maryland.

73. Computer-managed counseling, which is not interactive, is also used. Even if computers are not available for direct client use, counselors can use them for clerical and administrative tasks so as to reduce their paperwork loads, freeing them to spend more time with individual students and to administer capably large student populations. Fernuniversitat, the distance learning institution in

Germany, uses computers in this way.

74. Concern has been expressed about dehumanization of the counseling process, potential loss of confidentiality, and a tendency for students "to interpret the objectivity of the computer as evidence that the information obtained is completely valid and reliable." Yet, these new techniques show great promise in their tremendous capacity to store and retrieve as well as to select, sort, and combine information quickly, accomplishing tasks that are humanly impossible.(30) Their use may well become more widespread at colleges and universities in the future.

75. The capability of the NIT to provide immediate and comprehensive access to a broad range of information and data bases for both students and faculty is already having broad impact on higher education in those countries where such systems are available, notably Japan, Canada, the United States and Great Britain. Japan provides a number of examples in this area. The University of Tokyo Computer Center has developed a consolidated academic journal catalog data bank (TOOL-ULP), and TSS interactive search access is possible from anywhere in Japan. Gifu University has developed a Japanese language data base which contains nearly 100,000 references in the fields of educational technology and educational psychology, with the resulting information also available at the Universities of Kyoto, Osaka, Tsukuba and other places. A similar, broad-based data system, DIALOG, has been produced and is maintained by a private business in the United States and is widely available on American college campuses through the school library.

76. The same OECD Member countries noted above are in various stages of experimentation and operation of another NIT, videotex, which is being tested by a few colleges and universities. Videotex allows the home television set to function like a computer terminal and retrieve text information and graphics from a remote database. Since 1977 the Japan Telephone and Telegraph Corporation has been conducting experiments aimed at the development of CAPTAIN, an interactive videotex system which utilizes the telephone to transmit information into the home. CAPTAIN service is scheduled to begin in April, 1984. The Japanese are also experimenting with VRS (Video Response System). Since the CAPTAIN system relies on the public telephone network, it primarily involves written and graphic displays. VRS, however, will have its own dedicated circuits, making it possible to furnish moving images and audio information as well. It doesn't take too great an imagination to visualize the educational capability of such an interactive tool, but VRS is on the leading edge of experimentation and not actively used to provide higher education.

77. Operating videotex systems are being used by colleges and universities, however. In Canada, the University of Manitoba uses the Canadian videotex system, TELIDON, to deliver distance education. In the United Kingdom, the PRESTEL system provides access information about colleges and universities.(31) At present videotex has little

widespread impact on higher education institutions, but its use may grow in the future.

78. Computer networks are in operation in a number of Member countries. British authorities report many connections between their universities where most are connected to one of the two National Centres at the Universities of London and Manchester. There are also regional networks interconnecting the universities in particular geographical regions. The interconnection is carried out by dedicated lines, hired from British Telecom. Universities use these communication links for access to the large computers in the National Centres and also for access to expensive software packages and large data bases. They also report that a development plan has been drawn up so that connections can be unified to incorporate all universities and research council institutes.

79. In the United States, higher education computer networks are reported to be "growing in an uncontrolled, almost chaotic manner to support the expanding needs of scholars and administrators...."(32) Such networks are being used for resource sharing and communication among academics.

80. As with videotex, however, the use of such inter-institutional networks is concentrated in only a few Member countries at present. Because of the cost advantages, however, it can be expected that such networking activities will spread in the near future.

4. Strengthening Research

81. In the area of research, use of NIT has had a major impact on higher education institutions in nearly all OECD Member countries. First, the increasing amounts of computer equipment available to faculty at colleges and universities has generally spurred research efforts in many fields. And now that major data bases are more accessible via computers and the data itself more easily manipulated, academics in most disciplines are pursuing more sophisticated research topics than would have been possible previously.

82. Some institutions in the United States (Stanford University, for example) make microcomputers available to all faculty members, to conduct their own research at home or wherever they desire and to communicate with one another and with the university's mainframe computer system whenever necessary. The growth of computer networks in America has also been encouraged by individual faculty in specific fields of study, seeking to improve their own research capabilities and to communicate with their colleagues. Similar activities are occurring elsewhere.

83. Second, colleges and universities in most Member countries are in the forefront of research concerning the use and effects of NIT in education. For example, the majority of the specific research programs described by Morris in his discussion of the use of NIT in Scottish

education (33) were being carried out at Scottish higher education institutions. In the Netherlands the Centre for Education and Information Technology (COI) has been set up at the Technical University at Twente. Funded for a five year period, COI has a broad mandate of research and provision of information. Similar work is being done in nearly all countries, predominately in colleges and universities. France is the exception here where much of the research work on NIT in higher education is being done in separate research centers.

84. Unfortunately, recent cuts in research funding in many OECD Member countries have hurt severely. In a number of countries the government sponsored university-based research on higher education and the NIT. For example, the National Institute of Education and the National Science Foundation have both funded a number of research projects in the United States at particular colleges and universities. But such government research funding is declining. In Germany, the budget for all data processing projects under the federal Ministry of Research and Technology was 344.1 million DM in 1979, but had declined by 1982 to only 52 million DM.(34)

85. At least partly in response to the cutback in government research support and partly in response to other pressures, colleges and universities have begun to seek research support from business and industry. Such privately-supported NIT research is becoming an important factor in institutional budgets in a number of Member countries (Scotland, the Netherlands, Japan, the United States) The increasing number of relationships between higher education institutions and business will be discussed further below.

86. Overall, despite budget reductions, a substantial amount of research is being conducted, both about and using the NIT thoughout most OECD member countries.

5. Identifying The Faculty Role

87. Certainly faculty play an integral role in the development and delivery of courses, programs, and counseling provided using the NIT. Yet, studies in the United States and Canada have shown that many faculty participating in distance learning programs were teaching only part-time, and holding other jobs separate from their academic positions.(35)

88. The extent of faculty involvement in NIT curriculum development appears to be the result of a combination of conditions: the extent to which existing materials are used, the expectation that other faculty from the same (or other) institutions must be involved, the types of NIT used to deliver the instruction, and the relevant skills that the faculty member brings to the process.(36)

89. LeCorre and Schwartz note that, "at present, courseware is implemented largely by "amateurs", e.g. by middle-school teachers or

university professors, expert in some educational subject area, but new to the computer medium...."(37) These authors go on to describe the "compelling instructional style that the new technology affords," through the combination of many talents. The ideal situation, as they see it, would be to have a group to develop such courses which would include "a scholar deeply versed in the subject to be presented ...who must also be a talented and sensitive teacher.... These academic skills must be combined with the skills of graphic designers, with the image-oriented, "filmic" skills of the motion picture director, ...with actors able to read passages of text,...film clips, and in some cases the services of animation studios.(38)

90. Little wonder that some of the more "traditional" academicians blanche at the thought of educating students via the NIT. Some of the techniques and skills required are so foreign to those they have used in the past as tutors or classroom instructors. In the British Columbia study cited earlier, educators who were questioned about the satellite television delivered courses in use there said they felt such courses were "improved, being better planned, prepared, organized, structured and presented than the average lesson delivered in a regular class."(39) The use of this NIT required more organization, more advance planning and significantly more preparation time than would be required to give a typical class.

91. Examining patterns of faculty involvement and faculty resistance to use of the NIT in America, Lewis found consistent problems of faculty resistance to the use of telecommunications for instructional purposes in the programs he surveyed.(40) This study found some faculty who resist any sort of change, some who object specifically to certain aspects of the NIT (it's impersonal, it diverts resources needed elsewhere, it threatens my job), and some who simply feel uncomfortable because they are unfamiliar with the technology. Similar findings of faculty attitudes can probably be found in other OECD Member countries.

92. However, this survey identified a number of strategies that can help to overcome faculty resistance, strategies that have been used effectively at American colleges and universities. These include: providing for active oversight by departmental faculty; encouraging participation of prominent faculty in the project; utilizing full-time rather than part-time faculty as much as possible; using the NIT in the least complcated and least obtrusive way; targeting use of the technology to save time for faculty members; and offering an effective orientation program to participating faculty.(41)

93. Faculty acceptance and effective utilization of the NIT is an important part of the implementation process as higher education institutions adopt various kinds of these new media. The challenge for both faculty and institutional administrators is not an easy one, and it is clear that faculty must be centrally involved as the NIT are tested and installed on campus.

C. The Influence of Industry

94. Interaction between business and universities exists in most OECD Member countries. This interaction takes on special importance in the area of NIT as governments seeking to improve economic conditions and gain a place in the "third industrial revolution" directly or indirectly encourage close relationships between higher education and business.

95. At the same time, increasing budgetary restrictions and financial pressures placed by governments on colleges and universities force them to search for outside, additional sources of support. And business and industry, especially firms involved in the manufacture of NIT and the provision of related services, look more and more to higher education as a source of trained manpower and relevant research as well as a provider of services and a market for computers and other NIT.

96. This general topic is discussed in detail in the recent OECD study on new forms of cooperation and communication between industry and the universities.(42) Only a few aspects of the impact on higher education will be noted here.

97. Government efforts to encourage industry-university collaboration in the area of NIT technologies have been especially evident in the United Kingdom, Japan, and the Netherlands. A good example is in the Netherlands where, by order of the Ministry of Education, the Ministry of Economic Affairs, Philips and Control Data Crporation (Netherlands) will work with the Educational Research Center at the University of Leyden to conduct research on applications of the videodisc in combination with the PLATO CAI system.(43)

98. Colleges and universities in many countries are beginning to initiate contact (and subsequent contracts) with business, as part of ther fundamental mission in teaching, research and service, and motivated further by a need for additional revenue. The efforts of Rensselaer Polytechnic Institute and Brown University in the United States are often cited as good examples of institutions reaching out to industry in furtherance of common goals.

99. Examples where industry has taken the primary initiative to link with higher education occur as well. In some cases this industrial initiative is taken with a view to meeting immediate manpower needs. In Japan and the United States a different sort of effort is also underway, involving substantial donations (or discounts) of equipment to colleges and universities. The motivations of industry in this sort of program are usually mixed, but include the desire to establsh a market for their technology products on campuses as well as to encourage research. The Apple University Consortium (AUC) in America is a good example of this sort of arrangement. The AUC, which consists of 24 major universities, expects to place 50,000

microcomputers manufactured by the Apple Computer Corporation on its campuses by the end of 1984. Member institutions are expected to purchase $2 million each of Apple products at varying discounts over a three-year period. The plan is for students and faculty to use the computers for developing curriculum and new applications. Each university is required to develop instructional software on Apple computers and to meet regularly with other AUC members. Joining the consortium gave participating universities the opportunity to purchase the computers for significantly less than the retail price.

100. Whatever the source of the initiative, relationships between business and higher education institutions in the area of NIT are expanding in most OECD Member countries, with significant impact at a number of colleges and universities. In all likelihood these arrangements will continue to grow in the near future.

Section II

ISSUES FOR THE FUTURE

102. Given the trends of NIT introduction into higher education institutions, what public policy issues must be resolved in Member countries? What are the major questions still facing colleges and universities? The following sections of this analysis will consider these remaining questions - not so much with the notion of providing definitive answers, but instead with the hope that by raising these issues, enlightened debate can result.

A. Public Policy Issues

103. The previous chapter described current policy planning activities for NIT and higher education - the situation in a state of flux, and not a little influenced by the broader economic and political context. The focus of policy development, where it has occurred, has generally been on secondary, not higher education.

104. An important question here, then, is whether or not Member countries should now adopt a separate, specific policy (or series of policies) regarding NIT and their implementation in the higher education sector. Is it time to focus on higher education in these matters? Are the issues and concerns discrete enough for governments to be able to address them separately?

105. The questions are not easily answered. In France, higher education has been integral part of the broader NIT policies developed. In most other countries where some educational planning has been undertaken at the higher education level, however, such policy efforts have often been related only tangentially to planning efforts in other education sectors. And in a few countries (Sweden is an example) with extensive policies for lower education levels, little higher education planning has taken place at all. What are the merits of integrating higher education planning efforts into the broader educational policy development process?

106. Responses, of course, must differ depending on the current status of planning in each country. In countries where little or no planning has been undertaken at the national level (Germany, United States, Canada) the question may well be moot. In America, for example, Congressional attempts to enact various laws regarding higher education and NIT (the so-called Apple Bill and others) have not yet

been successful.

107. It can be argued that the purposes of goverment policymaking and funding for the various educational levels differ, and therefore can be addressed separately. Support for professional education (computer science, engineering) at the postsecondary level is usually designed to meet short-term manpower needs. Secondary education programs use NIT, but have quite different and broad goals for the long-term. But such arguments are probably too black and white. Governments fund technology programs at secondary schools with manpower requirements in mind, and support planning activities directed toward higher education with a view to improving the broad notion of education and learning. Separate goals and purposes for government policies at the different levels are blurred.

108. And, it is difficult to argue against the virtues of coordination and integrated planning, especially in the cases of those countries where bits and pieces of policy development have occurred so far. Commissions here, planning and advisory groups there - all studying and reporting on different aspects of the problem for different educational levels can only lead at some point to a babble of advice, sometimes conflicting. Perhaps the time has come for more coordinated policy development.

109. In some countries that might mean beginning (or emphasizing more strongly) a consideration of higher education's role as planning for implementation of NIT at other educational levels continues. In some countries it might mean stepping back to get a good overview of disparate activities in all educational sectors, with consolidation and coordination of efforts a logical next step. And in some countries it might mean rethinking once again the policy decisions made earlier to have little or no policies at all.

110. Italian officials, for example, note that "the political authorities responsible for education...have been particularly active in implementing interesting and varied ventures in the past, and are continuing to do so. As of this time, however, there seems to be no overall strategy that might impose at least some order and set overall goals for all this effort. This is likely to be the task before us now as a country...."(44)

111. As a part of this policy re-evaluation process, governments in Member countries will probably want to consider the following issues. Who should be the main agents of a national policy regarding higher education and NIT? Should it be ministries of education (perhaps in some form of cooperation with ministries of industry), state or regional authorities, local groups, or the higher education institutions themselves? What should be the divison of labor, and what degree of centralization or decentralization is required?(45)

112. A second public policy issue relates to the focus of support. Higher education institutions have up until now, concentrated on

professional education as the main area for NIT introduction. Should this educational mission of colleges and universities continue to receive the most emphasis in policy planning and governmental funding, or should more attention and monies be directed toward spreading the use and study of NIT into all fields of higher education study?

113. Third, what should be the role of central government regarding higher education and NIT? Several options are listed below which have been suggested as possible governmental roles:

- monitor developments in higher education institutions and elsewhere, including data collection, trends analysis, and other similar activities;
- assist in the setting of standards, possibly including machinery, software, communication protocols, etc.;
- perform evaluation functions, of higher education programs, software, courses, or learning itself;
- provide research support to colleges and universities (or elsewhere) for NIT studies relating to higher education;
- provide support for manpower training (teachers, professionals, technicians) in higher education institutions;
- provide support for general education about and/or using NIT to higher education institutions;
- provide support for equipment purchase;
- provide incentives to foster industry-university cooperation in the area of NIT;
- encourage cooperative efforts among institutions themselves, and between institutions and governments at all levels.

114. Depending on the options selected, governments can take a strong stance with regards to policy development and subsequent program support, or choose to adopt a lesser role, relegating some of the authority and responsibility to others (such as to other levels of government or to the higher education institutions themselves).

115. OECD Member countries have already begun the process of selecting and implementing options from this list. Irish authorities are encouraging close collaboration between higher education and employers, and "innovation centres and Micro electronics Application Centres have been established with some third level institutes to assist existing industry and entrepreneurs to develop" by using NIT.

The Netherlands' government is actively promoting inter-institutional cooperation. Evaluation and assessment will be important upcoming activities, report officials in the United Kingdom.

116. A fourth important issue must be addressed at the policy-making level - that of equal educational opportunity. In many OECD Member countries there are population groups which for various reasons (geographic location, income, race, previous levels of educational attainment) have been denied to opportunity to participate in higher education. The NIT have been mentioned by some as having the potential to lower barriers to participation for such groups, - easing their transition into higher education programs, providing distance education in the home or community center, etc. A recent American study has examined the potential of NIT in this regard and found it to be substantial. However, it seems clear that central government will have to take the initiative for support of policies and programs in this area, since higher education institutions themselves appear unlikely to have the incentive or the financial wherewithal to establish such educational opprtunities utilizing NIT.(46)

117. The recent efforts of the Finnish government to bring higher education to outlying regions are a good example of what strong policies can accomplish in this area. Also, the distance learning institutions established in a number of Member countries see improving access as one of their more important goals.

118. An overriding factor in all of this policy development process is that of costs. In most Member countries, the financing of these various policies and programs remains a major issue. Where will the money come from? With tight budgets and limited resources, the substantial costs of implementing a NIT initiative in the higher education sector will make any government pause and perhaps reconsider. Micros at every college, satellites in the sky beaming educational TV, videotex systems on a national scale - the financial resources necessary will be tremendous.

119. Understandably, government budget officials ask, "What are the benefits in relation to the costs?" While it is possible to make reasonable estimates of the costs of various policy alternatives, it is nearly impossible to estimate benefits. Too little is known at the present time about the value of learning via NIT compared to more traditional modes of education to permit such estimations, or about calculating the value to society of something such as 'computer literacy.'(47)

120. It is not even clear that government investment in manpower development by higher education institutions for specific economic sectors (such as high technology) pays off. (This issue will discussed further later.)

121. Thus, government officials in Member countries are often forced, when making decisions regarding higher education and NIT

support, to invest blindly in hope of significant return at some point in the future, but with no assurances and no guarantees. The risks are enormous.

122. Unfortunately, the risks are just as great if blind investments in such efforts are not made. And it is obvious that governmental decisions in this area are developed in a much broader context than just the education arena. The social and political context of each country comes to bear on the process, shaping policies in unique ways.

123. Certainly most governments will search for ways to share the costs and spread the risks. Some countries (if not all) will require colleges and universities themselves to bear at least part of the implementation costs. Some will seek to share the costs with regional and local authorities. And some, like the United States, will leave a major part of the initiative to private enterprise and to individual students who must purchase their own equipment. The magnitude of the total costs involved virtually dictates that Member country governments seek shared and perhaps innovative financing mechanisms.

124. It will be years before many of the critical policy development questions are resolved, and governments are wise to realize that the NIT implementation process for higher education will undoubtedly be drawn out over a much longer period than originally expected by even the most thoughtful observors.

B. Institutional Issues

125. Despite the substantial impact NIT introduction has had on all aspects of college and university systems - mission, functions, educational material, research, and faculty - much potential lies ahead with many inherent issues and problems.

1. Expanding Mission

126. Professional education, attractive from an institutional viewpoint as meeting government and societal demands for technical manpower and attractive to students seeking readily available jobs, has been in the forefront of higher education's initial response to the advent of the NIT. But is this the way of the future? Should it be? This is an issue which needs to be addressed by institutions as well as by governments.

127. The higher education sector has had difficulty responding in the past to short-term manpower needs in many countries. The problem is partly one of time lag. Demands for manpower in specific economic areas develop. Colleges and universities respond. It takes a year or more to develop a responsible curriculum (and get it approved). It takes two to four years to enroll the first group of students and graduate them. By the time significant numbers of trained college graduates actually reach the workforce, the demand for manpower in

that particular area has often slackened or shifted. Other sectors, able to move more quickly than the higher education system, have filled the demand (including short-term institutes, training programs already located in business and industry, etc.). In some cases the manpower forecasts on which the whole effort was based were themselves in error. The higher education sector doesn't deal well with such problems.

128. In addition, short-term perceptions of demand sometimes don't fit the long-term facts. It is possible that in a number of Member countries there will be a declining need in the overall job market for college graduates, as is already the case in the United States. Over the next decade in America, for example, most of the jobs available will not be in the professional categories. Occupations producing the most new jobs will be secretaries, nurses' aides, janitors, and salesclerks. Even in high technology job areas specifically, the two categories with the highest expected percentage growth are data processing mechanics and computer operators, neither category requiring a person with a college degree. The coming of the Information Age, at least in the United States, is not going to trigger great increases in numbers of jobs available in absolute terms.(48)

129. So there appears a bleak vision of colleges and universities rapidly gearing up in the United States, and perhaps in other OECD Member countries to train too many professionals in NIT professional fields, often with government support. While the problem may be overstated here and manpower demand will surely vary across countries, at least the issue can be stated this way: Should the major emphasis of higher education institutions remain on training of professional NIT manpower? Would it not be wiser to diversify, as it were? Should it also be acknowledged that while the coming Information Age many bring new manpower demands of unknown strength and duration, it will more assuredly bring profound change to all aspects of society?

130. Education for understanding the implications of these elemental changes may be the more important role for colleges and universities in the next decade. Should not the use of and study about the NIT be integrated more carefully and fully into a wider range of programs offered in higher education institutions? Students could be prepared broadly for the world of work - not so much for any particular job category but more liberally to provide them with flexible skills to cope with a rapidly changing world where use of the NIT will be ubiquitous.

131. The expanding mission of higher education might also utilize the NIT more fully to reach out to 'nontraditional students' - working adults and others who will need and demand new skills and new training in an evolving work environment. As shown by the various distance learning institutions already in operation, the NIT appear well suited to assist other, more traditional higher education institutions to reach potential new students, thereby improving educational

opportunity for certain populations and possibly offsetting declining enrollments of younger students to at least some degree.

2. Searching for Content

132. Of all the important issues facing higher education about the NIT, one of the most crucial must be answered by colleges and universities themselves, through their research, their experiments, and their experience. The issue can be phrased this way: do the NIT make a difference? Can they be used to improve education - the transmittal of knowledge and understanding? Does their use in teaching help people learn in ways that are significantly improved over traditional methods?

133. The search for answers to these questions must be pursued vigorously in the next few years, for why else are institutions implementing all the NIT if they don't make significant improvements? Given the vast sums being invested, there is a certain urgency about the search for answers, hopefully positive! It is one thing to take risks and invest blindly before machines and techniques are proven, but it is quite another to forego the subsequent 'proving.'

134. Alternative mechanisms (various kinds of computers, television, videotape or videodisc, etc.) abound and can be used in endless combination. Content can be well developed or of poor quality. Certain courses or fields of study may (or may not) lend themselves more readily to devlivery via the NIT. For example, it has been suggested that remedial courses and scientific courses relying on graphics and simulation are particularly well suited to presentation using computers or other similar mechanisms. Is this true? Certain groups of students may be better served using NIT, some suggest, while others point out the new media work particularly well for distance education. Then there is the basic question - to what extent is human interaction necessary for effective learning? This issue has been raised since the advent of courrespondence courses, but must be studied anew in this new context.

135. Society as a whole must rely on higher education institutions to study all these variables and to demonstrate what works best and what provides little if any improvement given the cost. Quality of the educational software is an important factor here, since it will do little good in a research sense, to test the effectiveness of the NIT using poor quality content.

136. All the above discussion is not meant to suggest that higher education has not yet even begun the task of proving the NIT's worth. Limited amounts of research and evidence from demonstration efforts are beginning to appear. But much more needs to be done before educators and others can feel satisfied that the NIT will in fact improve higher education.

137. Another point must be emphasized. The issue has been framed

thus far in terms of effectiveness of use. But a related issue must be addressed. Will the study about NIT by students in colleges and universities improve their overall "education"? Computers and the other mechanisms will play an increasingly important role in everyday life over the next decade in most OECD Member countries. How much should college students study about this phenomenon? Again the question must be raised in many fields of study - sociology, anthropology, economics, to name only a few. The world is growing smaller as NIT are used more extensively. Higher education institutions are ideally suited to explore the implications. The potential for change in education curricula is substantial.

138. Based on the assumption that the NIT do have a place in education, colleges and universities must continue to define their role in the production of educational materials, including courseware and additional services such as counseling. Will the higher education sector accept the development role here, or will the initiative be taken instead by government, research institutes, or private enterprise? This issue will undoubtedly be resolved in the next decade.

139. And what is higher education's development role beyond its own sector? To what extent should higher education be responsible for developing courses for primary and secondary education or for other sectors of society - government or business and industry? It can be argued that colleges and universities have a key part to play in developing primary and secondary education programs (as they train teachers) and in developing education and training materials for governments and private enterprise. Again the intent is not to suggest that higher education has not engaged in such activities in the past. Of course it has. The question is one of future level of effort. How much more should institutions be engaged in such development?

140. The pressures for colleges and universities to do more in this area are strong. Institutional Schools of Education seem competent to do that work for lower educational levels. Practicing teachers in primary or secondary education have little time for such efforts. And pressures on higher education institutions to develop learning materials for business and industry have also been strong due as much to the need for institutions to find new sources of revenue as to industry's demands for courseware.

141. So the challenge and the opportunity to take a major and increasing role in content development for the NIT is facing the higher education sector. Will colleges and universities accept the responsibility in the years ahead? Competition is growing rapidly, and institutions must decide quickly what the extent of their role will be, or lose the opportunities to a large degree.

3. Strengthening Research

142. The issues of needed research is inherent in the discussion of

the other problems already noted in this chapter - policy decisions, governmental roles, and effectiveness and quality of courseware.

143. Dissemination of research results is an important issue not discussed previously, however. Studies, experiments, demonstrations and pilot projects are getting underway all over the world concerning higher education and NIT. The mechanisms themselves offer unique and substantial communications potential. Yet there still remains a significant problem of dissemination of results among interested government officials, college educators and administrators, with too much "re-inventing of the wheel."

144. The NIT both call for and present exciting and innovative opportunities of communication on an international scale among researchers and program planners. It is possible to envision a higher education ERIC-type system - accessible in various OECD Member countries - which would go beyond literature citations to include reports of research in progress, results of evaluations and pilot projects, and access to relevant data bases located internally in each country. A college administrator comtemplating the use of CAI at his institution could examine results of its use in another, far-flung college without making the effort a long-term project spent in the libraries of several countries. Will higher education institutions collectively be able to accept the responsibility and establish such a research network on computer? Will governments in Member countries need to play a role? These are questions to be addressed in the next few years.

145. A second research issue which should be raised at individual higher education institutions is the extent to which faculty and students will be provided access to the NIT for research purposes, including access to the emerging computerized data bases. The investment costs are considerable and the question of who should pay will certainly be asked. Many institutions will choose to share the costs among administrative budgets, and faculty and students themselves. But however paid for, new standards of quality for research efforts are beginning to dictate that these tremendous data and literature resources be utilized. Colleges and universities can only expect demands to expand for such research opportunities from both faculty and students, especially as the availability of means of access (micros equipped with modems) increases.

4. Identifying the Faculty Role

146. Higher education institutions must face squarely the issue of faculty resistance to implementation of the NIT and do so quickly. The task is not insurmountable (though perhaps formidable). The previous chapter of this report noted a number of techniques which have proven effective in American colleges and universities. Most would appear transferable to institutions in other Member countries.

147. Beyond these, however, any positive results of the research

called for in the previous pages on the subject of NIT effectiveness can only help soften faculty resistance. Who can blame teachers for hesitating to use mechanisms the value of which is not yet well documented and the use of which requires substantially more time? Certainly there are faculty at institutions in most Member countries who use NIT and use them well. Admittedly there are those faculty members who will never be persuaded to teach via videotape, or whatever. Usage will never be universal. But a basic, positive attitude on the part of faculty must be established at colleges and universities. Lacking such acceptance, effective utilization of these mechanisms will be difficult if not impossible.

C. The Issue of Industrial Cooperation

148. The impact on higher education institutions of industry's interest in NIT is already substantial and growing. High tech industry-sponsored research centers are sprouting at colleges and universities. Equipment donated by companies is being tested and evaluated on campus. Institutions are busy developing high tech training programs for employees of business, to be delivered either at the institution or at the work site. Professonal continuing education programs are expanding. Faculty are increasingly hired as industry consultants. What does all this mean for the very nature of higher education?

149. Surely the old vision of the "groves of academe" far removed from the work of work is fading. Probably this is a positive development, a wise response to charges of unreasonable remoteness from reality that have been leveled at institutions in the past. Clearly the changes are being hastened by economic necessity. Higher education is an expensive enterprise, and there are finite limits to the abilities of students to pay. Research priorities demand costly equipment, and in few areas are the costs as high as in the study and use of NIT. Pressures (sometimes political, sometimes ethical) to provide community service push institutions into collaboration with local industry, as well as desires on the part of educators to provide real world experiences for students.

150. And yet, there is a sense among some viewing the scene that the idea can be carried too far. Nowhere is this more a possibility than in the area of the NIT. It is easy today to visit colleges where the new technology research center is funded by a cooperative effort of ten companies, the microcomputers in use by students are all donated or provided at discount by the equipment manufacturer, and the computer research underway is being conducted by faculty under a government military contract. The question arises: who has control here?

151. Such institutions stoutly proclaim their independence, of course, defending their industrial and governmental ties while preserving their intellectual freedom. And in most cases, the college

or university is, in fact, uncompromised by such relationships. But the trends for increased collaboration in the future seem clear. So more and more institutions may find it necessary to review their position vis a vis business and industry, if they wish to preserve some measure of academic separation. The issue could be an important one at some institutions in the years ahead.

D. Prospects for the Future

152. There could be tough times ahead for higher education institutions in relation to the NIT. The demand for research results is strong, but the resources to conduct the necessary studies are being cut. The demand for professional training in the field is strong, but it may only be a short-term phenomonen, better addressed by training conducted in the workplace. The demand for education opportunities by adults is strong, but the NIT offer great opportunities for learning directly in the home, separate from any higher education institution. (Evidence is already growing that many more adults watch educational TV programs offered as courses by local colleges than actually sign up with the school to take the course for credit.) The demand for cooperation with business and industry is strong, but contains some inherent dangers. And finally the demand for cooperation on an international scale is strong regarding the development and use of the NIT, but immediate prospects for such large scale cooperation across country boundaries are dim.

153. The actual scenario over the next decade is not likely to be quite so bleak. Institutions of higher education in most if not all Member countries can be expected to play a significant role as the NIT become more widely available, accepted and utilized. Government policies will undoubtedly recognize to a greater extent than at present the importance of higher education's contribution to these developments.

154. The impact on colleges and universities may be considerable, changing long-held views of student learning styles, faculty roles and administrative structure. The issues to be addressed are substantial, but the prospects are exciting.

NOTES AND REFERENCES

1. Countries responding to this section of the survey include Belgium, Finland, France, Iceland, Ireland, Japan, Scotland, Sweden, Turkey, and the United Kingdom

2. Varley, Donald E. "The Universities in Western Europe: a personal view of certain trends," in European Journal of Education, Vol. 15, No. 1, 1980.

3. Markham, James M. International Times Herald, February 22, 1984, Paris Edition.

4. Varley, op. cit.

5. OECD, 1983, and 1982.

6. Cerych, Ladislav, Computer Education in Six Countries: Policy Problems and Issues. Paris, France: Institute of Education, June 1982.

7. Report to the Minister of Education by Le Corre, Yves and Claude Pair, 15.10.1981, Ministry of Education, Information Service, Paris, France.

8. Education and the New Information Technologies: provisional draft. Paris: EEC, 1983.

9. Shain, Irving, "National Information Policy Issues and Higher Education," in EDUCOM Bulletin, Vol. 17, No. 1, Spring, 1982.

10. For an overview of European national policy developments, see Cerych, Ladislav, op. cit.

11. Department of Education and Science Press Notice 299/82, 16 December 1982, and 302/82, 21 December 1982.

12. Cerych, Ladislav, "Computers in Education: major problems and key policy options," in European Journal of Education, Vol. 17, No. 4,

1982.

13. Lewis, Raymond J., Meeting Learners' Needs Through Telecommunications: A Directory and Guide to Programs. Washington, D.C.: Center for Learning and Telecommunications, 1983.

14. Ibid.

15. Ibid.

16. Most of these institutions are described in CRE-Information, No. 64, 4th Quarter, 1983.

17. For details of Fernuniversitat's operations, see Peters, Otto, "Tradition and Technical Innovation - The Fernuniversitat in Hagen, West Germany," in CRE-Information, op. cit.

18. Northcott, Paul, "Applications of technology to distance education at Deakin University, Australia," Paris: OECD, 1983.

19. van Schalkwijk, Harry, "The Correct Use of New Technology," in CRE-Information, op. cit.

20. vand der Drift, Koen D., "Education and automation: status and opinions," University of Leyden, The Netherlands, n.d.

21. For similar Dutch findings, see also Akkermans, Jaap and Jef Moonen, "Computers in Education: The Netherlands", Workshop Council of Europe, Frascati, November, 1982.

22. O'Shea, Timothy, "Computer Aided Learning in Distant Education," in CESTA, Applications des Nouvelles Technologies a L'Education Multimedia, March 1983.

23. For a detailed study of costs, see Eicher, Jean-Claude, "Economic Aspects of the Introduction of NIT in Education," Paris: OECD, CERI/NT/84/06.

24. Feasley, Charles E., Serving Learners at a Distance: A Guide to Program Practices. Washington, D.C.:ASHE-ERIC Higher Education Research Report, 1983.

25. Goto, Tadahiko, "SIS-TEM III-A Computer-Based Educational System," in Educational Technology Research, Vol. 4, Nos. 1,2, November 1980.

26. van Schalkwijk, op. cit.

27. For more information on the software issue, see Le Corre, Yves and Jack Schwartz, "Software and Courseware," Paris: OECD, CERI/NT/84.05.

28. Forsythe, K. and V. Collins, British Columbia - Higher Education and the Integration of a New Technology. Victoria: November, 1983.

29. ERIC/CAPS, "Counseling In A Hi-Tech Age," in CAPS Capsule, No. 3, 1983. See also Christoffel, Pamela, "New Technology and Adult Learning in America: Can Barriers Be Lowered?" Washington, D.C., 1983.

30. ERIC/CAPS, "Counselors and Computers," in HIGHLIGHTS, An ERIC/CAPS Fact Sheet, 1983.

31. See "Electronic Text and Higher Education: Lessons from the United Kingdom," in TELESCAN, Vol. 3, No. 1, September/October, 1983.

32. McCredie, John and William Timlake, "Evolving Computer Networks in American Higher Education," in TELESCAN, Vol. 3., No. 3, January/February 1984.

33. In The European Journal of Education, op. cit.

34. Gorny, Peter, "New Information Technologies in Education in the Federal Republic of Germany," in the European Journal of Education, ibid.

35. Feasley, op. cit.

36. Lewis, op. cit.

37. Op. cit.

38. Ibid.

39. Forsythe and Collins, op. cit.

40. Op. cit.

41. Ibid.

42. "New Forms of Co-Operation and Communication Between Industry and the Universities," Paris: OECD DSTI/SPR/83.82.

43. van der Drift, op. cit.

44. In Education and the New Information Technologies, op. cit.

45. Similar questions in a broader context are raised by Ceryich, "Computers in Education," op. cit.

46. Christoffel, op. cit.

47. See Eicher, op. cit.

48. Arbeiter, Solomon, "Guns, Butter or Sheepskins? The Military, Business and College Competition for High School Graduates in the 1980's," in The College Board Review, forthcoming. See also the work of Rumsberger, R.W. in The Job Market for College Graduates, 1960-1990. Palo Alto: Stanford University, 1983.

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Overview in Selected Member Countries,
Analytical Report on the Survey
and Proposals for International co-operation

RESEARCH AND DEVELOPMENT RELATING TO THE EDUCATIONAL APPLICATIONS OF NEW INFORMATION TECHNOLOGIES

(Note by the Secretariat)

1. At the first meeting of the Advisory Group of national representatives and experts held on 13th-14th September, 1982, a proposal was made to include in CERI Project 1 a specific activity on "the nature and size of current investment in R & D on advanced educational applications of the computer" (CERI/NT/82.06 paras. 17 to 19). This proposal was endorsed by the CERI Governing Board at its 27th Session in November 1982 [CERI/CD/M(82)2 para. 74 (ii)], one of the underlying assumptions being that, in addition to its intrinsic value, such information, if it would be put together, would provide the basis for any discussion about possibilities for future international co-operation in this area.

2. For the purpose, a questionnaire (CERI/NT/83.06) was drawn up and sent to a number of research institutions via the authorities concerned in countries interested. This paper briefly analyses the responses received by

the Secretariat, then suggests some possible forms of international co-operation. Annex 2 to CERI/NT/84.04 provides, in a uniform layout, some key information on R & D activities by each of the institutions participating in the survey.

3. This report, prepared by the Secretariat, will serve as a background report for the Plenary session on Theme 4.

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INTRODUCTION

1. Over the last 10 years, computers and telecommunications have widely infiltrated socio-economic activity in services, communications and production. The process is accelerating, perhaps more rapidly than might have been expected. This confronts the education system with new industrial, marketing, economic and cultural pressures, and with new social expectations. The challenge is all the greater as the market is already lavishly supplied with video games, calculators, video recorders, and microcomputers with an educational character liable, unless something is done, to create a new sphere of "education" outside the formal system.

2. During the 1960s and 1970s research was already in hand on audiovisual applications to education and on teaching applications of computers, in order to identify more closely their potential. Nowadays, the background to research and development here is naturally very different. Programmes are generally designed:

i) To advance the application of information technology to generally accepted educational purposes;

ii) To facilitate the incorporation of information technology in the educational process as an end in itself, to meet the vital requirement that young people should acquire awareness of, and familiarity with, information technology;

iii) To encourage, in particular, developments and applications which support other social aims, such as improving equality of opportunity and, conversely, to indicate instances in which developments might have the opposite effect;

iv) To advance our understanding of the learning process, of the acquisition of "false knowledge", particularly in relation to computers as a learning tool.

3. However the ultimate aims of R & D programmes are defined, the direction of development of information technology will not be determined primarily by educational considerations but will result from outside pressures and influences: hence the strategy for educational R & D must be to maximise the educational benefits of developments taking place external to education.

4. At present there is a wide spectrum of activity in some developed countries but the programmes which have been embarked upon, and which are showing evidence of considerable effect, are not in the main based upon research. They are to a great extent developmental; the advent of the new information technologies has been so rapid, and their relevance to education so manifest, that school systems, teachers, pupils and parents, encouraged by direct government action, have adopted them with enthusiasm on a sufficient scale to make this one of the most significant influences on education in recent years. This is not of course to say that the effect is universal, or even widespread; change in education is slow, and as with any innovation there are plenty of questioning voices. In order to provide the answers to those questions, and in order to give sound advice to the innovators, a broad programme of research and of training linked to research is necessary.

5. Indeed, the nature of research in an area such as this is dependent on there being a range of activity in the field, and good research should be related to work going on in the teaching environment and should also itself offer opportunities for associated training, not only of potential research workers but also of teachers and others who need to come to terms with the new developments. Educational research can seldom be conducted at arms length, and such a stance would be wholly inappropriate in this area.

6. The following report starts by presenting some proposals on the R & D carried out in selected countries, revealing trends in which certain similarities can be observed. The second chapter reviews the findings of the survey of Member-country research institutions. On the basis of the information and conclusions of Chapters I and II, the report ends by suggesting possible topics and arrangements for research and development on a co-operative international basis.

Chapter I

FINDINGS AND PROPOSALS FOR SELECTED COUNTRIES

7. Certain governments have recently sought to find out more about how far the new technologies have developed in their education systems, and to assess recent experiments. Various agencies were accordingly requested to suggest what future guidelines should be laid down so as to achieve the best possible degree of control over the introduction of these technologies into education and to maximise their educational potential. From all the resulting reports, a number of conclusions for R & D emerge around the following points.

Need to Develop Research

8. In the United States, in October 1980, the Office of Technology Assessment (OTA) was instructed by the United States Congress to review the potential role of new information technologies in education. Reporting in November 1982 (US Congress, Office of Technology Assessment, Informational Technology and its Impact on American Education), the OTA noted that "in the late 1960s, the Federal Government funded a number of research and development projects in the use of computer assisted instruction. Over the last decade, Federal funding for R & D in educational information technology has dropped precipitously"... "Much remains to be learned about the educational and psychological effects of technological approaches to instruction. Not enough experience has been gained with the new information technology to determine how that technology can most benefit learners or to predict possible negative effects of its use. Given this insufficient experience, caution should be exercised in undertaking any major national effort, whether Federally inspired or not, to introduce these new technologies into education". The OTA advised Congress to consider developing policies designed to ensure optimum use of technology and i) directly to support R & D in those areas; ii) to encourage private sector investment both from the foundations and from industry; or iii) encourage a combination of both by using Federal funding to leverage private investment.

9. In November 1982, the national Pittsburg conference "Computers in Education: Realising the potential" sponsored by the United States Department of Education came essentially to the same conclusions as the earlier OTA work: "Realising the full potential of the computer in education requires ground-breaking research that will allow educators and manufacturers to proceed confidently in the development of advanced computer-based materials for the schools. Earlier Federally-supported research provided the basis for the computer-aided instruction of the last decade and a half. Another such

research programme is now needed to take advantage of the vastly increased capability of affordable computers" (Computers in Education: Realising the Potential, US Government Printing Office, June 1983).

10. In June 1983, M.W. Sage and D.J. Smith presented a report to the United Kingdom Social Science Research Council (SSRC) entitled "Microcomputers in Education, a Framework for Research", one of whose conclusions was that "much recent development has taken place in the absence of substantial research. Attention is drawn to the lack of a formal basis for the design of learning experiences ... It is argued that the fundamental need is for research which will contribute to the information base and theoretical models which will improve the design and implementation of learning experience based on information technology applications in a variety of contexts".

11. In France, in October 1981, Y. Le Corre and C. Pair presented the Minister of Education with a report entitled "L'introduction de l'informatique dans l'éducation nationale" (Introducing computers into national education) (Service de l'Information du Ministère) in which they stated that "research on teaching applications of computers should be developed and enhanced with a view to:

- -- Developing worthwhile facilities, with an eye to product quality and to remedial applications;
- -- Preparing for the cultural and industrial effects;
- -- Controlling adverse aspects, such as accentuated inequalitites, robotisation, threats to privacy".

12. In November 1983, R. Carraz presented the French Minister of Industry and Research with a mission report "Recherche en éducation et en socialisation de l'enfant" (Research on child education and socialisation) (La Documentation Française, Paris) in which the need to develop R & D associated with educational applications of the new information technologies was emphatically stressed, "the aim of R & D being not to see how hardware can enter the education system at all costs, but to what extent it could improve learning and education; how it could be prevented from fostering new forms of inequality and what effects it would have on the functioning of the school (learning processes, special content and subject areas)".

13. In January 1984 in the Netherlands, the Ministers of Education, Science, Economic Affairs, and Agriculture and Fisheries published a white paper "Informatics-Stimulation Plan" (ISP) presenting their Information Technology policy for the period 1984-1988. The paper states that "given the priority for education and information technology, one can say that that support by means of research, including policy evaluation, is at present insufficient".

14. It is interesting to compare these proposals with the recommendations emerging from CERI work in this R & D area in 1970. A CERI seminar at Portland, Oregon, United States, in October 1970 concluded that:

> "It is considered essential for the future development of computer-based learning that there should be more planning of the research programmes and financial support than they are given... One

> significant aspect of the research that has not been given its due attention in the past is research which looks at questions oriented toward the problems of instruction in the context of ongoing instructional programmes. Most of the research in the past, it seems fair to say, has been research which has been oriented towards specific problems that are examined outside of an ongoing instructional programme but have presumed relevance to such programmes. This type of research needs to be given support as well but should not be the exclusive type of research that is supported and programmed in the larger plans on a national or international basis." (CERI, Technical Report of Portland Seminar, June 1971).

In Existing and also in Future Institutions and Centres

15. There is accordingly a need to develop R & D in education and the information technologies, and to start by strengthening existing teams. Here it is noteworthy that in 1984, the United Kingdom University Grants Committee allocated 46.5 teaching posts to information technology for the forthcoming academic year, and that 35 of these were mainly to strengthen research in the area. It is also relevant that the UK Government has accepted the recommendations for the "Advanced Information Technology Programme" in the report of the Alvey Committee (1982) and that £ 200 million will be available for the five years ahead.

16. The various reports all emphasize the need for co-ordination, at national level, of research between universities and other public sector, and also for links to be developed between the public and private sectors. To facilitate the co-ordination of research fragmented among a variety of teams and institutions, and also to encourage the multidisciplinary and interdisciplinary approach by bringing together scientists in different disciplines -- cognitive psychology, computing, artificial intelligence, education sciences -- some countries are contemplating new R & D centres. The Pittsburg Conference in the United States concluded: "The successful application of computers to education will require expertise in subjet matter, in teaching, in computer technology, in cognitive science and in design. It is therefore necessary to provide means for bringing individuals with these capabilities together into team efforts. To accomplish this objective we recommend establishment of at least two research centres dedicated to applying technology, and new knowledge of human cognition to improving education". To ensure healthy competition between ideas as well as good geographical access, two centres were recommended, one predominently for research on new applications of the computer in reading and writing and one predominantly for comparable research in mathematics and science. As a result of that recommendation, the first centre has been established at Harvard University in the mathematics and science field (see Annex 2, United States).

17. In the United Kingdom, the SSRC also reported that research programmes would require "a high degree of multidisciplinary collaboration" and that "there is a strong case for the establishment of a technology centre, inter alia dedicated to multidisciplnary research into aspects of the educational significance of information technology, with particular emphasis on the principles underlying the design and implementation of technology-aided learning experiences." That recommendation was accepted, and decisions about

the funding, size and location of the centre are expected during 1984. During its first phase, the centre is expected to circulate research findings, and to harmonize these with the needs of users and decision makers.

18. In the autumn of 1981, the French Institut National de Recherche Pédagogique (National Educational Research Institute, INRP), published a report "Dix ans d'informatique dans l'enseignement secondaire, 1970-1980" (Ten years of computing in secondary education, 1970-1980, INRP, 1981, Série Recherches Pédagogiques) which assessed the French "58 lycées" experiment. The report concluded that pedagogical research ought to be co-ordinated at national level by a multidisciplinary team. The research Director of the Ministry of Education, at a large scale Paris seminar on computers and education in November 1983, further to that conclusion, said that because computer-assisted education was multidisciplinary, the importance needed to be stressed of pedagogical research (mainly conducted by the INRP). It should be borne in mind that the cultural and economic impact of computer-assisted education might lead on to work in the human sciences. The Ministry of Education wished to structure that research by programmed topic activity contracts, which the Research Directorate would undertake jointly with the Ministry of Industry and Research, particularly its computer agency. A preliminary attempt at co-ordination had been in hand for more than twelve months under Professor J. Arsac; this involved some 30 researchers in teams, in different geographical locations, investigating specific problems in teaching computing by CAI methods.

19. Also in France, the Carraz report recommendation was to establish a National Educational Research Institute with more resources than the existing Institut National de Recherche Pédagogique, and differently designed. Within the new Institute a multidisciplinary centre would be established to specialise in research into pedagogical use of the new technologies "to ensure consistency among the many research avenues and the best possible co-ordination between the various teams and programmes (universities, INRP, National Educational Documentation Centre (CNDP), Mathematics Teaching Research Institutes (IREM). The centre's purpose should be to investigate and identify research needs, develop new languages and new educational hardware, and to provide teachers with help and advice. These research activities would only be feasible if conducted in association with the schools themselves, and involving researchers in subject-area teaching methods. A key component would have to be differentiation in cognitive learning styles so as to infer relevant pedagogical applications for the new technologies". The report to the Minister adds that the multidisciplinary centre would need substantial resources to promote its policy and would therefore require a net increase in the established posts at its disposal over the number at present allocated for research in this field.

20. In Australia, a proposal for the establishment of a research centre for the study of computer applications in education is under consideration by the Minister of Education and Youth Affairs and the Minister of Science and Technology. This centre will involve several universities, and the Commonwealth Scientific and Industrial Research Organisation.

R & D in the Following Fields

21. Each of the reports mentioned above lays down priorities and research proposals for its own country. It may be helpful to introduce them briefly so that in conjunction with the survey results, chapter 3 can identify possible topics for international co-operation.

22. In the United States, the Office of Technology Assessment concluded that there was a need for R & D focusing on:

i) Developing new techniques and tools for software development;

ii) Developing the human/machine interface;

iii) Improving the understanding of cognitive learning processes.

23. The Pittsburg Conference recommended the Federal Government to pursue research in the following directions:

i) Prototype research which will provide the necessary knowledge and experience for subsequent development of instructional systems and materials by private industry and schools, and fundamental research in laboratory settings on processes involved in skilled reading, writing, mathematics, science, and other intellectual activities; new ways to adapt instruction to individual differences in aptitude and progress in learning, and the psychology of student and teacher interaction with automated instructional systems;

ii) Associated fundamental research in specific activities from which shorter-term payoffs can be expected, e.g. the enhanced design principles for human/computer systems for education;

iii) Research on cognitive issues:

- Resistance to the changes involved in this type of learning;
- Improvement of understanding, reading and writing;
- Knowledge structure;
- Mental models;
- Cognitive psychometrics.

iv) Research into other areas including motivation, the introduction of computers into education, the computer as an aid to the teacher, teacher training, school and class organisation, quality and assessment.

24. In the United Kingdom, the SSRC report suggests two directions for research:

i) Learning processes, assuming highly interactive software, focused on the styles, strategies and process of learning with information technologies. This would involve investigating individualised learning, distance teaching, associated information handling skills, software conceptualisation principles, social interactions, expert systems for education;

ii) The impact of technologies on curriculum and the efficient management of changes in educational practice and organisation.

25. In addition, the Alvey Committee, the Scottish Microelectronics Development Programme, the Scottish Council for Educational Technology, the Microelectronics Education Programme and the Council for Educational Technology are working on a wide range of software research (design, distribution, etc.), curriculum, teacher training, information and communications systems (Prestel), etc;

26. In France, the Le Corre - Pair report suggests research into:

-- Terminal specification (especially videodiscs);

-- Features of communications media;

-- Nature and presentation of information for exchange;

-- Man/machine interaction for education, information and documentation;

-- Forms of distance teaching;

-- Educational software design;

-- Problem solving;

-- Educational games;

-- Social and psychological aspects;

-- Involvement in local community;

-- Ergonomic aspects;

-- Assessment;

-- Special applications to various categories of the handicapped.

27. Meanwhile, the Carraz report suggested:

i) Putting work in hand on diversified ways of using the computer in teaching situations, starting with an inventory of existing practices;

ii) Closer analysis of mechanisms for expressing and understanding audiovisual messages, taking account of learning styles and of how the neurosciences are beginning to describe those mechanisms physiologically;

iii) Further work on the use of the re-recordable videodisc;

iv) Studies of the use of computers as part of teaching practice;

v) Studies of the underlying operational concepts (memory, programme, switching, coding etc.) and the various forms of awareness and construction by pupils: taught or self-developed;

iv) Introducing these technologies and educational applications within a broader cultural framework (technical culture dimension);

vii) Investigating arrangements for introducing technologies as training tools in industry;

viii) Pursuing the consolidation of work on artificial intelligence, cognition and educational software design with a view to devising expert systems and languages with which the user can program more independently.

28. In the Netherlands, the Informatics-Simulation Plan considers research projects in the following areas:

i) Applications of information technology to special education;

ii) The development of hardware, software and courseware in association with the industrial sector;

iii) Experimental projects giving practical results for an immediate demonstration effect.

29. Here again, attention is drawn to the 1970 Portland CERI Seminar on key R & D areas:

> "... the area of research that needs further development is that which is designed to look at both sides of the teaching/learning process, namely the instructional aspects and the students learning aspects as an interactive and two-sided operation. Research which relates learning to its avowed function is essential if we are to develop appropriate theories of teaching and theories of learning in cognitive development. Over the past decade our perceptions of what the computer might do in education have matured; ... there is a need to move off a base which has been primarily delivery systems oriented to ask sounder and more far reaching questions. Questions which computing systems could contribute to in a material way and in a way which would be different qualitatively to that in which the psychology of learning and cognitive processes have been developed in the past. The computer can give us a powerful tool for looking at interactive processes in ways that the media and other approaches do not. We need to think of

computers as instruments for developing the thinking processes; to serve individual differences in teaching styles and learning needs; and to stimulate creative activities in teachers and students. Computer-based learning has unfortunately inherited all the problems of education, and revealed them like a microscope showing that the resources necessary, and particularly the conceptual resources, for constructing an important and useful educational enterprise just do not exist."

Chapter II

TENTATIVE ASSESSMENT OF THE STATE OF RESEARCH AND DEVELOPMENT IN SELECTED MEMBER COUNTRIES

30. Since resources and time available preclude a very detailed picture of the various R & D activities in the new information technologies as applied to education in Member countries, this chapter presents information and trends emerging from contacts with research institutions in those countries expressing interest in such work. Accordingly, information was sought about the nature and scope of R & D programmes, as a basis for determining:

-- Areas where there are sufficiently active groups in Member countries to make an international co-operation programme possible;

-- Areas where there is need for an enhanced research effort.

31. For this purpose a questionnaire (CERI/NT/83.06) was devised in three parts. The first sought particulars of research groups (address, names of researchers, work already performed and recent publications and theses) and of the level of activity (budgets, funding sources and man/years). In the second part, research institutions were asked to classify their work under five broad categories:

i) Hardware for educational purposes;

ii) Systems for educational applications;

iii) Educational application software;

iv) The learning process;

v) Social and psychological issues;

vi) Programmes directed at professional development and training.

In part three of the questionnaire, the respondant was asked to summarise the group's work in under 500 words (CERI/NT/84.04 Annex 2).

32. The questionnaire was sent out in September 1983 to the various institutions, through the authorities in the countries concerned. The latter were Australia, Belgium, Canada, France, Ireland, Japan, Sweden, the

United Kingdom and the United States, (which offered a representative sample of R & D work). Questionnaires were received back between December 1983 and June 1984.

Main Findings from a Limited Survey

33. The survey was limited, first in not covering all OECD countries, and this largely accounts for the substantial differences observable between those countries that are already largely computerised, across the various socio-economic sectors, and other countries, but even the former display appreciable differences in the extent to which information technologies have been introduced into education (cf. CERI/NT/84.02). The survey was also limited by the fact that in the countries concerned, a number of research institutions either were not contacted or did not reply, or omitted some details they regarded as confidential. Lastly, the survey did not cover, deliberately at this stage, research in private sector computer firms, or in large public or private enterprises. Nevertheless, in the opinion of the authorities of the countries concerned, the information forwarded is representative of the type of R & D work, if not of the amount being conducted.

34. The survey covers a total of 122 research institutions of which 101 are universities (or higher education establishments), as follows:

Australia	17	of which	17	universities
Belgium (Dutch-speaking)	2	of which	2	universities
Canada	26	of which	25	universities
France	17	of which	13	universities
Ireland	2	of which	2	universities
Japan	25	of which	14	universities
Sweden	1	of which	1	university
United Kingdom	15	of which	15	universities
United States	17	of which	12	universities

Scale of R & D Universities

35. The first salient observation is the amount of interest the universities are taking in this type of R & D. The reasons are as follows:

i) Universities, long equipped with computers for fundamental research in physics and mathematics, later developed training for computer scientists. So they were already familiar with the computer as a tool. They naturally conducted the first experiments in computer-assisted education in the early 1960s and created the first software and courseware for their students, mainly in science. With the introduction of minicomputers and microcomputers into primary and secondary schools, universities used their long experience to create appropriate languages, authoring languages, software and educational packages, and sometimes hardware for primary and secondary schools;

ii) In a number of countries the universities are responsible for training information technology teachers for the schools;

iii) They have the necessary manpower resources for the multidisciplinary approaches required for R & D in these various areas;

iv) Education science faculties and departments feel that they are particularly concerned by this technological revolution and its consequences for teaching/learning processes and curricula;

v) They are expected to meet new training requirements for computer professionals and for those branches of industry which are rapidly evolving as the result of large-scale applications of the new technologies.

36 The universities' involvement here is a matter for satisfaction and in some countries may lead to stronger links between universities and society, especially industry, and between universities and primary and secondary schools.

Similarities, for Certain Countries, in the Number of R & D Institutions and Resources Allocated to R & D

37 Despite the many problematical aspects of this survey, the number of replies from institutions for each country was more or less the same. In other words, countries were taking about the same amount of interest in R & D for education and the new information technologies. A wider survey in the United States would probably have given a response rate of the same order, proportional to the higher number of research institutions there.

38. A brief review of such information as has been forwarded on R & D resource levels in terms of funding and man-years shows countries (see CERI/NT/84.04 Annex 2) to have four categories within which the research groups can be classified:

i) Smaller groups, most with no outside funding of between 0.5 and 3 man/years. Most of these are teachers researching in mathematics, physics and education sciences who have decided to focus their research on educational applications of the new technologies within their own teaching departments;

ii) Medium sized groups, many with more or less modest outside funding, of between 4 and 8 man years;

iii) Larger groups, with substantial resources, of 9 to 15 man years;

iv) Research centres and institutions with substantial financial and human resources, of 16 to 100 man years. Instances are the Harvard University's new Education Technology Center in the United States, the University of Calgary and the University of Waterloo in Canada, London University and the Open University in the United Kingdom, and the Institut National de Recherche Pédagogique, and the University of Paris VII in France.

39. This information must be treated cautiously, because not all institutions quoting resources in man/year terms specify whether their figure means the number of researchers per year or the number of researchers multiplied by the number of years the contract or programme runs. Harvard University, for example, quotes 108 man years for research over five years, i.e. about 22 researchers. Nevertheless, the human resources level would appear to be of approximately the same order in Canada, the United States, France and the United Kingdom, with the majority of research groups comprising between 4 and 8 man years and just a few very large groups. Australia seems mainly to have the smaller groups of 0.5 to 3 man years. Japan did not provide any information about human resources engaged in R & D.

Research Directions Generally Identical in Survey Countries

40. Part two of the questionnaire was designed to ascertain R & D directions. Annex I is a quantitative analysis of the 192 responses covering 117 institutions, some institutions covering more than one research centre, faculty or department. The University of Calgary, for instance, sent in 23 replies which were accordingly taken into account. For reasons concerned with the analysis of research activities in the various areas (listed in paragraph 31) as percentages of the total number of responses per country, countries with only one or two research institutions, i.e. the Dutch-speaking sector of Belgium, Ireland and Sweden, could not be included. Part Two, therefore, deals only with the following six countries: Australia (21 responses, 17 institutions), Canada (76 responses, 26 institutions), the United States (17 responses, 17 institutions), France (25 responses, 17 institutions), Japan (30 responses, 25 institutions), and the United Kingdom (23 responses, 15 institutions).

41. Since this report is intentionally geared to possible international co-operation, it neither discusses the broad R & D directions of individual countries nor makes any comparisons between countries. The reader is referred to Annex 1, which shows some interesting differences for particular research subjects. But those do not appear to undermine the following conclusions. On the basis of average percentages for all six countries, for every item under each of the main headings, R & D research areas can be ranked as follows:

a) Between 65 and 75 per cent of activities

-- 74 per cent of the R & D groups were involved in the use of the computer as a learning tool (CAI) [(ii)(a), Annex 1];

-- 65 per cent in educational software development [(iii)(a)].

b) Between 40 per cent and 50 per cent of activities

-- 49 per cent were involved in the identification of input and output devices [(i)(a)];

-- 43 per cent in CAI authoring languages and computer managed instruction [(ii)(f)];

- 40 per cent in computers applied as laboratory instruments, and for data processing, CAD etc. [(ii)(b)];
- 40 per cent investigating man/machine interaction [(iv)(c)].

c) Between 30 per cent and 39 per cent of activities

This range includes:

- Using the new technologies to individualise education: 39 per cent [(iv)(a)];
- Training teachers to use computers: 39 per cent [(vi)(d)];
- Developing new hardware: 36 per cent [(i)(b)];
- Using data banks, viewdata etc.: 33 per cent [(ii)(d)];
- Using computers for remedial and handicapped pupils: 32 per cent [(ii)(c)];
- Using computers to diagnose learning difficulties: 30 per cent [(iv)(b)].

d) Between 20 per cent and 29 per cent of activities

- The impact of computers on learning processes (improving, understanding): [(iv)(f)] 28 per cent; [(iv)(d)] 25.5 per cent; [(iv)(e)] 20.5 per cent; [(iv)(g)] 20 per cent;
- Activities relating to the social and psychological aspects of introducing the new technologies: [(v)(a)] 26 per cent; [(v)(c)] 23 per cent; [(v)(d)] 21 per cent;
- Activities relating to professional training programmes: [(vi)(c)] 28 per cent; [(vi)(b) 22 per cent; [(vi)(a)] 22 per cent;
- Distance learning and telesoftware: [(ii)(e)] 21.5 per cent.

e) Between 8 per cent and 19.5 per cent of activities

- Hardware portability, protocols and standards, including distance learning applications: 19.5 per cent [(i)(c)];
- Software and courseware portability: 18 per cent [(iii)(c)]; distribution techniques and processes: 15 per cent [(iii)(b)];

-- Other social and psychological questions, such as new responsibilities for families: 17 per cent [(v)(e)]; equality of opportunity: 15 per cent [(v)(f)] and changes in school organisation: 17 per cent [(v)(b)];

-- Ergonomic and medical aspects, only 8 per cent [(i)(d)].

Conclusions from questionnaire analysis

42. In accordance with the aims of the survey (cf. paragraph 30), general conclusions emerging are that:

i) The resources being allocated for R & D in educational applications of the new information technologies seem low in view of the challenge they represent for education;

ii) Fields in which countries have enough research groups to envisage co-operation are:

-- Computer-assisted education (CAI) in multimedia hardware configurations based on programming languages capable of developing student creativeness (e.g. Logo, MicroProlog-), educational software production, authoring languages and expert systems;

-- Use of the computer for a better understanding of and improvements to learning processes, to be applied first as a remedy to school failure.

iii) Fields in which R & D levels are found to be low are:

-- Distance learning;

-- Software and courseware portability, including telesoftware;

-- Social questions such as equality of opportunity for access to the new technologies in terms both of understanding and educational use, according to social and cultural background and sex;

-- Ergonomic and medical aspects.

Chapter III

INTERNATIONAL CO-OPERATION: NEEDS, RESEARCH TOPICS AND POSSIBLE ARRANGEMENTS

43. From analysis of the questionnaires and information contained in CERI/NT/84.04 Annex 2, and of R & D trends and proposals in the selected countries (see Chapter I), the following four broad research and development areas can be selected:

i) Software and courseware: design (pedagogical design, correction, preparation), tools (capabilities and utilities, programming languages, author languages, applications of artificial intelligence techniques i.e. expert systems), distribution (publishers, telesoftware, portability), quality control, uses (class, home), assessment and follow-up;

ii) Learning processes: use of the computer as a way of improving learning and as a research instrument with which to study the mechanisms of understanding and learning processes (study of differences between pupils, including remedy to school failure and the handicapped, individualisation of teaching, pupil/machine and teacher/machine interaction etc.);

iii) The use of the various new technologies for educational purposes: multimedia computer systems with a special emphasis on the re-recordable videodisc, distance learning (viewdata, satellites, optical fibres);

iv) Social and psychological aspects: especially equality of opportunity (boys/girls, different socio-economic groups, cultural and linguistic minorities) and resistance to innovation on the part of schools, teachers and parents.

Needs for international co-operation in R & D for OECD countries

44. There is a clear-cut distinction among OECD countries in introducing the new information technologies into the education system: one group is very advanced at all levels of the education system, another group is very advanced at the professional and technical education level, and a third group has not yet taken any significant decisions (cf. CERI/NT/84.02 and 03), partly because of doubts about the effectiveness of the technologies but also because they

cost so much to introduce (cf. report CERI/NT/84.06). In other words, assuming an irreversible trend towards introducing the new information technologies into education, and the need to derive the maximum advantage from them to improve learning, it is essential that international co-operation be useful both to the most advanced OECD countries and to the least advanced.

45. International co-operation in R & D should be both short-term and long-term. The least advanced countries have an immediate need for the experience -- successful and otherwise -- of the more advanced to determine their policies and strategies. At the same time, co-operation is needed in fundamental research geared to the future rather than to the present.

46. International co-operation should involve public sector research institutions including certain schools and teachers, together with the major public and private sector enterprises with long experience of using the new technologies in initial and continuing training. This is a really important point. Whether in developing educational software, using the various possibilities, produced with the aid of a variety of means such as videodisc, telecommunications, voice recognition etc. [man/machine interaction, graphics illustrations and digital pictures, laboratory experiment control, computer-assisted design (CAD), machine tools, robotics, telecommunications] or in assessing the results, including cost analyses, enterprises will be a source of much information that is not readily available in the formal education system, which would have a great deal to gain from it.

Possible research topics with which to make a start on co-operation

47. Various areas would lend themselves to co-operation, as mentioned in paragraph 43, but it would seem preferable to select, not necessarily exclusively, precise and restricted topics for the first phase, realistically and in the light of existing R & D. In the first phase, therefore, it is suggested that work should be done on prototypes with which to improve hardware and software for possible use in the following fields:

i) Arithmetic;

ii) Reading;

iii) Computer literacy;

iv) Elementary mechanics;

v) Physical geography;

vi) Boolean algebra;

vii) Foreign languages;

viii) The interface between microcomputers and simple and complex machinery.

48. These fields are suggested because they tie in with the need mentioned above for international co-operation. The latter would involve developing highly interactive software, whose cores could be transferred unmodified for

different hardware configurations, thereby ensuring portability, from the teaching standpoint, from one country to another, with countries making themselves responsible for any additions necessary to reflect teaching, cultural, social, historical or geographical considerations of their own. It would be hard to overemphasize the importance of achieving pedagogical portability of software from advanced countries to the less advanced countries, since good software costs so much to devise. Needless to say, agreements should be concluded among the advanced countries about copyright, so as to make transfers to the less advanced countries acceptable.

Possible Arrangements for International R & D co-operation

49. Generally speaking, for the topics that the Conference might select (see paragraph 43) the next steps in the short term might be:

i) To set up specific international teams (four to five researchers) by topic, to advise Member countries upon request on any of those topics;

ii) Regular exchange of information about the state of research on particular subjects:

-- by distributing the proceedings of major conferences organised by Member countries;

-- by appropriate telecommunications systems among the researchers themselves;

-- by having the researchers meet once a year.

In this connection it is worth pointing out that universities and other research institutions in Member countries have already developed international contacts and wish to strengthen those links, as was mentioned in several of the survey respones.

50. More specifically (see paragraph 47), for the above proposals relating to co-operation on software and courseware, there would be a need to identify:

i) A few Member countries (some very advanced, others much less) interested in this form of co-operation;

ii) One or two subject areas, i.e. arithmetic, elementary mechanics (because of the sophisticated simulations already available in certain countries for the latter) and foreign languages;

iii) The institutions (universities, public institutions and private and public sector enterprises) in participating countries with experience in these fields.

51. Whatever the arrangements decided on, substantial funding would have to be envisaged to prepare and implement such international co-operation effectively. If such co-operation were to prove successful, even though on a modest scale at first (1985-1986), it could obviously lead later on to more ambitious substantially funded R & D programmes in international institutions

and centres, which the countries concerned could consider setting up, recognising the need to put together their experience and resources on this highly complex and costly issue. As a first step it would be useful if interested Member countries agreed to set up an ad hoc group to follow up the conference conclusions in this area and formulate, together with the Secretariat, precise and realistic proposals for further action.

Annex 1

Quantitative Analysis of Responses to Part Two of the Questionnaire

Country	Total questionnaires analysed	Total research institutions
Australia	21	17
Canada	76	26
France	25	17
Japan	30	25
United Kingdom	23	15
United States	17	17
	Total 192	Total 117

The following percentages under each heading (i), (ii), (iii), (iv), (v), (vi) and items (a), (b), etc. are calculated from the total number of questionnaires analysed. For example, under heading (i) item (a), the percentage for Canada is 49. This means 49 per cent of the 76 responses, i.e. that 37 research departments are working on the same topic: identification of available input/output devices.

Research and Development Areas	Australia	Canada	United States	France	Japan	United Kingdom
	(percentages calculated by country on the total number of replies per country)					
i) Hardware for Educational Purposes						
a) The identification of available input/output devices having educational applications.	48	49	59	8	50	55,
b) The development of new or the identification of prospective devices that may have a radical effect on education.	38	44	41	32	20	41
c) Identification of needs for protocols and standards to facilitate the interconnection of equipment and the transferability of materials, including protocols for electronic data communications (e.g. for distance education).	19	30	12	16	13	27
d) Ergonomic and medical aspects of the new information technologies in their educational context.	14	11	0	0	10	14
ii) Systems for Educational Applications						
a) The use of computers in interactive learning applications such as direct instruction, exploratory learning environments, simulations, gaming, etc.	81	76	82	82	47	72
b) The use of computers as process control devices in technological and scientific studies, as tools by students in carrying out calculations, contructing graphical presentations, writing and correcting essays and in computer-related activities such as computer-assisted design.	38	44	59	24	30	41
c) The use of computers to meet the needs of individuals with specific learning difficulties or physical handicaps.	43	26	41	32	20	32
d) The use of retrieval systems such as data banks, question banks, videotex etc. and the development of skills in information handling.	48	32	30	20	40	27
e) The applications of communication systems, including both the more advanced educational use of existing systems such as telephone tutoring, teleconferencing and telesoftware (delivery of computer programs through the telephone system or the broadcasting networks) and the educational applications of advanced communications systems such as Direct Broadcasting by Satellite and Fibre Optics.	24	33	18	12	20	22
f) The application of information technology to improve the efficiency of the production of learning materials and in educational administration including student management (e.g. authoring languages, curriculum development systems and student performance monitoring systems).	62	48	47	36	26	41
iii) Educational Application Software						
a) The development of educational courseware products using computers, videodiscs and other presentational devices either alone or in combination.	67	63	82	72	57	50
b) Processes and techniques of distribution.	10	18	18	12	10	22
c) Transportability between systems, including translation between different programming languages.	19	27	18	20	6	18

Research and Development Areas	Australia	Canada	United States	France	Japan	United Kingdom
	(percentages calculated by country on the total number of replies per country)					
iv) The Learning Process: Exploration of the use of computers and related technology as a means of promoting learning and as a research tool for studying the process of learning						
a) The study of individual differences in aptitudes and performance and the use of technology in supporting adaptive learning.	33	30	65	28	33	32
b) The uses of computer technology in the diagnosis of learning difficulties.	38	18	47	40	20	18
c) The study of learner/machine and teacher/machine interaction.	38	27	47	52	20	55
d) The use of technology to collect and analyse data on learning behaviour as a basis for developing models of human learning.	19	24	29	24	20	36
e) The evaluation of curricula by computer based monitoring of learning.	24	17	29	0	26	27
f) The use of computers in modelling intellectual processes.	19	18	41	36	20	36
g) The impact of teaching computer science in general education, on the learning process.	24	19	23	20	14	18
v) Social Issues: Research on the social and psychological factors involved in introducing new educational technologies into existing social systems						
a) The study of resistance to technological innovation (particularly by teachers).	33	22	30	12	10	32
b) Changes in school organisation and school architecture brought about by the new information technologies.	10	13	35	8	13	23
c) The changing role of the teacher in the new technological school system.	24	20	35	20	6	32
d) The changing role of the educator in the new technological school system.	24	21	47	4	10	18
e) The changing role of the home and school in the development of childrens' learning.	14	6	53	4	3	23
f) The impact of the new information technology on equality of opportunity with respect to sex, minority groups and geographically isolated individuals.	28	8	30	8	3	14
vi) Programmes Directed at the Professional Development and Training in Educational Applications of the New Technologies Including Programmes Related to Research and Programmes Related to Teaching Activities						
a) New programmes or new course elements in existing programmes aimed at the training of specialist professionals.	24	26	47	20	3	14
b) Training of teachers in computer science.	28	20	23	28	6	27
c) New programmes or new course elements in existing programmes for non-specialists.	38	27	35	24	13	32
d) Training of teachers in using computers.	57	30	47	44	6	50

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SOFTWARE AND COURSEWARE FOR A MULTIMEDIA EDUCATIONAL ENVIRONMENT

(Note by the Secretariat)

1. The attached document has been prepared by Yves Le Corre, Professor, University of Paris VII, France, and Jacob Schwartz, Professor, of the University of New York, United States, in their capacity as consultants to the Secretariat. It will serve as a background report for the Plenary session on Theme 2 and Working Group 5.

2. The views expressed are those of the authors and do not commit either the Organisation or the national authorities concerned.

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PREFACE

Since this report has to go into some technical aspects of computers, and of their educational applications in computer-assisted instruction (CAI), the following annexes may be helpful:

-- Annex 1: Acronyms;

-- Annex 2: Basic glossary of computer and CAI terms for readers new to this field;

-- Annex 3: Additional glossary of computer and CAI terms for those wishing to pursue the points made in greater detail.

1. Great strides have been made in applying the new technologies to education, and to training, as a result of the rapid, varied, efficient and economic interactive capabilities of computers. It is these interactive capabilities that need to be exploited for the purpose of analysing, identifying and correcting the learner's responses to different types of situation, such as discovery, learning, testing, reinforcing, creating, applying, practice, etc., using such methods as tutorial, simulation, modelling and routine games.

2. Educational uses of interactive multimedia (CAI in the broad sense) also comprise computer-based learning and training (CBL, CBT) in a narrower sense, such as interactive retrieval from databanks, teaching games, business games, and LOGO (the programming language in which a child can make discoveries from the outcome of the instructions given).

3. At the present time some tens of thousands of hours of CAI time (in the broad sense) are available worldwide, from teachers and also from the thousand or so commercial sources. Dozens of major service companies are working on CAI, as are dozens of publishers, many co-operating internationally, and CAI has about a dozen specialist journals. Something like one hundred newspapers carry articles about it and courseware package assessments. Several governments already have or are contemplating courseware libraries to facilitate exchange of information and packages.

4. The two major criticisms of CAI are high cost and poor quality. Hardware costs have dropped appreciably since 1960 when CAI first appeared, to their present levels of:

-- Viewdata: $200 for black and white; $600 for colour;

-- Home microcomputer: $250 to $1 000;

-- Desk-top computer: $1 000 to $10 000;

-- Mainframe computers: above.

To these must be added the costs of peripherals, a black and white or colour VDU (an ordinary television set if necessary), perhaps a printer, slide projector, tape deck, video recorder, videodisc, sound synthesizer, voice analyser (though so far this can recognise only a few words spoken by the user). A microcomputer with peripherals for classroom use costs between $300 and $3 000. On top of this may also be added the cost of any tele-communications necessary, charged for at local rates for viewdata and slightly higher for the specialist networks. Extra costs are incurred for access to programs, about $1 for viewdata or ordinary databanks, $10 to $200 for many of the micocomputer diskettes and sometimes much more, especially if custom produced by a specialist firm.

5. For the same level of quality, the expense of the central computer has been dropping considerably every year, but the expense of many of the terminals, and of the education products themselves, has fallen much less. The latter depends mainly on cost price and scale of distribution. Costs are high because distribution is on a small scale. Distribution is on a small scale because, even though these products may be of potential interest to considerable numbers of buyers, their educational quality is dubious.

6. This economic consideration can change very rapidly. It is only recently that a few management (not education) packages have become good enough and easy enough to use for sales to reach hundreds of thousands. CAI products are not yet at this stage. However, there are just a few which do perform satisfactorily, on low unit-cost hardware.

7. The following are available on viewdata:

i) Arithmetic and grammar exercises corrected immediately. Depending on how the student answers, similar appropriately-graded exercises may be offered;

ii) Fuller courses, involving the same kind of interaction, though with no branching to different grades of difficulty;

iii) Teaching games, akin to the simplest supplied with a home computer (hardly any animation);

iv) A training course for a basic metals company undergoing industrial renewal (which has its own local network).

Those education packages can run on a home computer.

8. Tutorial education using the microcomputer with a printer or some equivalent kind of display has met with severe setbacks. The first reaction of teachers was to prepare a program representing, simply and individually, what they themselves would say, with requirements they themselves laid down. But a student at a computer does not fit exactly into that situation, and the range of responses available was usually too limited (multiple-choice

questions, words to complete, etc.). However, with progress over the last 20 years, and the advent of sufficiently powerful microcomputers, open-response software can be produced with branching tailored to the pupil's needs and potential. Further progress is still needed in the analysis of responses and of conditional branching before any prototypes can be presented, but some acceptable packages can be found at an accessible cost to the school covering the grammar of various languages (mother-tongue and foreign) and for a small proportion of the secondary curriculum, covering sciences not requiring a graphics capability.

9. Tutorial education with projector and tape deck controlled by microcomputer (no graphic display) provides new possibilities: showing the slide rounds out what the teacher has to say, and offers more scope for interaction. The student can be questioned about it, and say which part of the picture is the answer to the question. The introduction of sound can also enrich the teacher's contribution and is important in a language lesson. Some good packages are available with slides, others with tapes. Packages are available for English and French as foreign languages; combining slides and tape and are very effective, although they have not as yet exploited the full potential of the computer-controlled tape deck.

10. Animation on home computers with colour screens has been developed in the English-speaking countries and more recently in France. Colour and animation add greatly to the scope for presentation, in explaining how many different kinds of processes work. Several dozen packages are on the market, many with very acceptable standards of graphics, on scientific, sociological and economic subjects. One of the most spectacular examples simulates molecules colliding with one another and with the walls of a vessel. The student can vary the volume of the vessel and the average speed of the molecules (and therefore the temperature). Collisions with walls are totalled and measure pressure. Molecule collisions with one another are also totalled over the time period and show the speed of the chemical reaction. Diagrams representing all these changes are very readably displayed on the screen. These simulations are outstanding, though most of them unfortunately do not come with any kind of interactive questionnaire with which to make sure at every stage that the student understands the meaning of every action he takes, what conclusions he ought to be drawing, and the danger in a simulation's departing too far from physical reality. Good quality packages have been produced, requiring some introduction and comment by the teacher using them, in, e.g., physics for higher education.

11. Another type of simulation relies on modelling a process, so that the student can discover its laws. The type described in the above paragraphs could also have used modelling, because the student's measurements show that the pressure in the model varies with temperature, inversely with volume, and with the number of molecules (but does not depend on their mass). "Mini-world" educational programs simulate experimental results in a world where the laws of physics may be different from ours and the student has to discover what they are. Several such packages are currently becoming available and they do effectively rouse the spirit of discovery in a way that no traditional teaching method can match.

12. Simulation is also used to show how various kinds of operation are performed. Several packages are available, some for the home computer: simple repairs (electrical, cars), chemical analysis (qualitative and

quantitative), and how to use a machine tool. Many packages are for more powerful systems:

- i) Learning to fly (and to cope with simulated emergencies), with a videodisc or numbered picture generator. It is noteworthy that some home computer reaction-skill games copying these now have exceptionally high quality graphics;
- ii) Learning to control a nuclear power station, with simulated breakdowns and problems on the various circuits.

13. Other educational applications have been designed using simpler equipment: the teacher can illustrate his lesson with a home computer as an "electronic blackboard" to display curves, diagrams, data, shapes moving in space. He can present a classroom experiment in which the measurements are clearly displayed through real-time digital processing, and show up the discrepancy between theory and the experiment. Good quality packages have been presented in mechanics, for the study of a few simple movements. That application can be developed by the pupil himself during the practical classes.

14. Still using a microcomputer (or merely a viewdata terminal), the pupil can access a databank and consult it interactively.

15. Another application is learning to read and, in particular, speed-reading. Here the microcomputer uses the possibility of displaying characters for a length of time controlled by the program in accordance with the subject's reactions. A related application is learning to type. Several commercially available packages measure the stroke rate, adjust the pace at which words are presented for typing and then gradually speed up. The packages currently available do not seem to be exploiting the full potential of a system which can not only detect spelling and typing mistakes, but also spot difficulty in typing particular characters or character sequences, and accordingly offer exercises emphasizing the difficult character or sequence.

16. Other interesting educational applications have utilised more complex systems. For example, an English-style analyser sets standard tests and has been found helpful by business users. The system advises on verbal and grammatical expressions to avoid, and where a long sentence would benefit from being divided up.

INTRODUCTION

1. This report deals with the educational applications of new information technologies based primarily on the use of interactive audio-visual systems. The interactivity is generated by a computer which asks the student a question so as to obtain a response which enables it to ask a further question. The scenario is produced by computer-controlled audio-visual equipment, i.e. slides, cassette recorder, video machine, videodisc, display screen, sound or speech synthesiser. The student replies by means of a keyboard, a screen controlled by touch or cursor, voice input, etc.

2. From the educational standpoint, interactivity first means analysing the student's responses: wording of an answer, closeness to a numerical value, how a diagram is modified, what shape is touched on the screen. The next stage in interactivity is the assessment built-in by the author, and selection of the next question or suggestion. Interactivity is also reflected in the possibilities offered the student, such as preference for a particular type of presentation, calling up various kinds of help (dictionary, calculation facilities, different presentation, going back to an earlier stage, an overview etc.). Interactivity is also reflected in the author's built-in decisions on whether or not to meet the student's wishes. These decisions may depend on previously assessed behaviour.

3. The computer and its input/output peripherals constitute the hardware. The audio-visual instructional dialogue developed by the author and structured to take into account the characteristics of the student and his responses in the courseware. The software controls the presentation and reception of the courseware on the terminals.

4. The first experiments date back to the early 1960s, which saw for example the introduction of Computer Managed Instruction (CMI) where the student, on the basis of automatically graded pre-tests and post-tests using multiple choice questions (MCQ), was urged to take a given standard course or revise a particular lesson. These years also saw the launch of LOGO, a computer language for children, and computer-assisted instruction (CAI), which was originally intended for the computerising of programmed instruction but which soon revealed the scope for far more diversified teaching strategies. CAI can be a tool for use by the teacher in the classroom or by the student in school or at home, or a tool for use in continuing occupational training.

5. It should be borne in mind that some other terminology is current in English:

-- CAL for Computer Assisted (or Aided) Learning;

-- CBL for Computer Based Learning;

-- CBT for Computer Based Training.

The present trend is to regard CAI and CAL as covering all the presentation side, independently of educational management itself which comes under the new definition of CMI: information about the student, choosing the educational software to provide, the strategy for branching decisions, the material needed for student and software assessment. Thus computer-based training (CBT) provided by firms for employees covers both CAI and CMI.

6. Today's rapidly advancing electronic technology is making profound changes in the economics of information storage, computing, and information display. We are now seeing gradual development of the necessary hardware for widespread introduction of computer-assisted education.

7. This technological development offers many potential advantages to education: a fresh approach to the costs, diffusion of education to new venues including the home, much improved educational quality in remote communities, the possibility of very wide provision of training in the new technologies, packages which provide sensitive individualised instruction, and detailed information on learner behaviour previously unavailable to the educational psychologist. However, investment will be needed to capture these potential advantages. While video games have grown into a $5 billion industry, computer-aided instruction, which is supported by many of the same technological trends (including cheap microprocessors and high-quality graphics), is still a largely static area.

8. Two main reasons for this difference can be asserted:

i) CAI systems developers have not made effective use of the exciting, fast-paced graphics environment central to the video game industry. Partly because the equipment available to CAI developers has been inferior, typical CAI systems do not integrate all the facilities that would create a favourable learning environment (colour, voice and music output, video images, split-screen and multi-screen displays, etc.). These facilities are not enough to create good teaching but it is noteworthy that, when properly used, they are of great help in getting the educational message across;

ii) The cost of creating high quality courseware is still very high, thus most currently available courseware is mediocre. The cure for this problem will require a substantial up-front investment in improved courseware-writing tools. (Some of what is wanted is outlined in Section V of this report.) It has taken a great deal of effort to realise that a good educational package can be something more than a skilfully programmed lesson on a computer, or interactive reading of a text-book. Educational games, simulation using animation, problem-solving, analysis of arguments emerging from artificial intelligence methods have opened up new horizons which will be discussed further later on, and have shown that certain teaching strategies require the use of a computer. One must also expect production of really high quality software to require TV-studio-like teams incorporating many specialists: subject-area experts, talented teachers, graphic artists, software experts, educational psychologists, and others.

9. A programme aiming to move beyond the present stagnant situation must have three main aims:

i) To create really first-rate interactive multimedia computerised learning environments;

ii) To define and construct much improved courseware production tools (education packages presented and processed by computer);

iii) To produce a number of model lessons constituting new suggestions for top-quality courseware.

10. Although progress on point (ii) will undoubtedly be slowed by the need for serious technical study and by complex implementation problems, choice of just the right project would allow rapid dramatic progress toward (i) and (iii), at least with a few "showcase" examples. This would set computer-aided instruction on the path to the major industry which it is likely to become. But the main reason for setting out the above targets must be the need to ensure that these developments aim in the first place at improving the efficiency of the teaching process.

11. Presently, most CAI courseware designers are attempting to build highly constrained miniature systems which can run on today's computers, and even on tiny personal computers. Even though the commercial pressures that lead to this concentration are clear, emphasis on today's machines is a very poor way of exploring the true potential of CAI technology. To prepare for the possibilities that the next few years will open up, we need to "lead" the rapidly moving hardware "target" substantially, by writing software and creating courseware not for today's machines, but for systems that will be typical five years or a decade from now. It must nevertheless be borne in mind that today we are far from exploiting all the possibilities of existing personal computers, even when the educational packages for which they are provided have been produced on much more powerful computers. We also need to take educational software very seriously and strive to create "classics" which can be used for years in the future by people of very different training backgrounds, ages and motivation, differences that will have to be properly reflected in the way the package converses with its users. Finally, we need to design CAI software systems that emphasize machine independence and transportability in a way that will allow courseware written today to carry forward to tomorrow's superior hardware.

Section I

ADVANTAGES OF INTERACTIVE MULTIMEDIA EDUCATIONAL ENVIRONMENTS

12. The rapidly advancing electronic technology of information processing and display offers many potential advantages to the educator:

i) Most fundamentally, it may allow the steady rise of educational costs to be moderated, through partial replacement of the artisan-like work of teachers labouring in individual classrooms to a more highly profitable system able to make effective use of powerful tools. Failure to deal successfully with the issue of productivity in education must inevitably lead directly to reduction in the real income of teachers, followed by declining student achievement and lagging economic growth. Computer technologies can improve productivity in education. It may be objected, by reference to audio-visual aids, that this argument does not necessarily prove valid in practice. It is worth pointing out that the most commonly mentioned shortcomings of audio-visual aids are:

-- First, the difficulty of rapidly obtaining the film or tape, of scanning it like a book, of adapting it to its target audience and of updating it;

-- Lack of interactivity, so that the student just listens or watches passively.

So long as there is no large volume of educational software of demonstrably sufficient quality, reluctance to spend money on it will be justified. This applies to the initial outlays necessary for developing prototypes, and also to institutional outlays on hardware, telecommunications systems and operation. It must however, be borne in mind that there are already a few good quality educational packages for home computers;

ii) By creating powerful educational packages accessible through interactive multimedia systems both in schools and at home, one can change part of the traditional venue of education, moving it from the school to the office and home. Continuing home education will thereby be strengthened considerably, and education will become less dependent on the centralised school setting. Education will become available in many places, and at all hours. This is very important for anyone living in isolation, in an inaccessible area such as an island, mountain or desert, and for those who feel uncomfortable in a school environment. The microcomputer can be freely accessible at home or in a library, but it does not seem desirable to contemplate extending that possibility. The school environment has qualities of openness, companionship and discipline which no microcomputer or network could replace;

iii) Although creation of courseware packages sophisticated enough to match the intuitions of a sensitive tutor is a very challenging task, the computer is capable of providing a kind of individualised education very different from the lockstep group progress of the classroom. This can prove a great boom both to the gifted student, who wishes to move ahead at an untypically rapid rate, and to the slower student, who the classroom may presently discourage by depriving him of the explanations he needs once his class has moved beyond his real level of understanding. A properly designed CAI environment can leave the student far freer to select a presentation order and supplementary materials meeting his personal needs than is the case in a standard classroom. Ideally, the computer can be experienced as a sensitive, infinitely patient tutor, able to use exciting graphics and fast-paced styles of emphasis to develop a high level of student motivation. In particular, students found to be deficient in one or another skill can easily be provided with additional study aids and practice material, which can be brought to them in a favourable, informal psychological environment at a time and place of their own choosing. Nevertheless, individualised education is not without drawbacks. The student is not the best judge of the right teaching style for him, and ought to be able to compare himself with his fellow students. The high fliers stimulate the rest and, conversely, are themselves stimulated by the classroom environment. No microcomputer can handle all the students' reactions, such as unstructured answers, requests, doubts or questions. So the student does not try to do anything unstructured, though he might be glad to be able to put questions to a teacher with enough time to listen, understand and inform. Individualised education therefore needs to derive partly from the computer itself and partly from the fact that the teacher, released from various tasks by the computer, can give each student more time, in a relaxed atmosphere;

iv) Computerised instructional systems are capable of collecting an enormous mass of data concerning student response and progress. A student's rate of progress along many separate educational paths -- reactions to particular questions, requests for additional information, and even detailed reaction times -- can all be monitored. This mass of data can be extremely valuable to the educational and psychological researcher: it allows the teacher to diagnose the educational difficulties of individual students; and allows progressive experimental improvement of interactive courseware. By recording and reviewing actual student interactions with a computerised educational system, detailed information concerning the effectiveness of various teaching strategies can be gained. Naturally, every ethical precaution must be taken. Recordings, even if anonymous, can only be made and conserved with the agreement of the students, parents and associations concerned. The problem is not the same in studying the package itself, or the students of a teacher (himself being tested), or for an individual student identified by name or code. The conditions are not the same when the information medium is held by the student, parents, teacher, school or research centre;

v) As is already the case in many national computer networks, computer systems accessible to large populations can serve as organising centres for many informal associations and clubs of students sharing common interests, taking the same courses, experiencing similar difficulties, wishing to share information, etc. In this way, man-computer interaction can facilitate constructive man-man contact. These points go some way to meet the criticism that computer teaching is dehumanising, a criticism that is largely justified, as only a part of education should be provided by computer;

vi) Computerised systems and communications media allow access to databanks for use in education:

-- Statistics on geography, the economy, society;

-- Local data on the history, development and population of the region in which the school is located;

-- Information on courses, careers, educational guidance;

The same precautions must be taken as with any documentary research: the data supplied must be matched to the student's level.

Furthermore, this possibility creates financial difficulties for the schools, which cannot easily control the costs it incurs.

vii) The student is motivated in his "encounter" with the microcomputer, and will refuse to let the machine have the last word, an attitude which does not wear off with the novelty of using these new technologies. But here again, this artificial encounter which may be more or less appropriately directed must be treated with caution;

viii) With CAI, new teaching approaches can be used, e.g. games, simulation, problem solving, random generations. The computer makes it easy for the student to compare experience with the theoretical model which is supposed to represent a preliminary approximation of reality. Certain concepts can be taught by traditional methods only to students with a marked aptitude for abstraction. By contrast, the computer makes it possible to get these across by means of interactive simulation controlled by the student himself -- this applies, for example, to statistical

> concepts (sampling, survey, risk, etc.). This is probably the best justification for using the interactive multimedia. The golden rule should be not to use them if one can manage just as well without them.

13. Here are three examples of education packages which could be produced in a few years' time with existing hardware and software. Comparable but simpler packages are already operational in a number of research centres. Example 1: A classical history lesson is intended to illustrate the power which the capabilities of the new information technology puts in the hands of the courseware designer.

> The student, in a college-level world history course, is reviewing the sequence of political events surrounding the collapse of the Roman Republic and the rise of the Principiate of Augustus. Some of the material is presented as straight text, which appears on the screen in an attractive book-like format, with single-frame illustrations, obtained from a videodisc storing up to 50,000 images, occupying roughly a quarter of the screen. This text material is enlivened by occasional (optional) quotations from ancient sources, for example Plutarch's Lives of the Noble Romans, presented in audio, quotations from each such source being read in the voice of a single actor who "represents" the ancient author. This material is announced on the screen by a line reading something like: "Concerning Crassus, Plutarch said the following...". This line appears in a colour which the student recognises as meaning that an optional audio insert is available. If he touches this line on the screen, the video illustration on the page switches to show a bust of Crassus, while Plutarch's remark on Crassus is read in a voice emphasizing its drama and irony. At a later point in the lesson, information concerning the Battle of Phillipi is presented, first by text explaining its significance, date, etc., then by 5-10 minutes of filmed material taken from the videodisc, and introduced by compelling musical fanfare. A map of Italy and Greece, showing the lines of march of the Republican and Antonian armies to the battle, is displayed. This is followed by a more detailed map of the area of northern Greece in which the battle was fought; then by film footage, taken from a helicopter, of the terrain of Phillipi. After this, a brief enactment of the battle itself is filmed, with views of its commanders in action, voice-over commentary on its main incidents, and dramatic scenes of the suicides of Cassius and Brutus. These film-clips then yield to text reviewing the significance of the battle and the events which followed it, with audio statements from ancient authorities reflecting on its meaning from the Roman world.

14. This didactic presentation is followed by an interactive multiple-choice quiz on the material of the lesson, until such time as virtually free responses can be accepted for so complex a subject. Questions answered wrongly trigger reruns of relevant portions of text, of audio, and of captioned video skills. In addition, the student has the ability to make abbreviated extracts of the text, audio, and video material presented, so as to build up his own personalised course summary for end-of-term review.

15. The second example involves simulation, in coaching tennis. The same method could be applied to many other subjects requiring know-how: craft

skills, surgery, laboratory work, etc. Various trial-and-error methods, tested and enhanced in the light of experience, make it possible to represent the movement of THE tennis ball chosen, struck by THE racket chosen with THE back-hand played by the player. Under that impulse, the ball flies through the air and bounces off THE tennis court surface. Other analytical methods feature the player's movement in making the stroke: position and speed of the racket and of certain parts of the body. These features are picked up automatically and processed by computer, in real-time or playback.

16. A data bank contains the characteristics of a number of tennis champions. Computer processing makes it possible, by superimposing an artificial picture, to examine the movement differences in slow motion. The computer immediately displays the remedial assessment of the movement, with immediate information about the success of the student's attempts and gives advice during the action itself. This kind of simulation is of value in other ways, making it possible to study changes associated with the equipment itself. Industries producing a very wide variety of court surfaces see a possibility of obtaining simple measurements with which to make the improvements asked for by users.

17. The third example involves application of artificial intelligence which, though still at the research stage, promises to open very broad possibilities for CAI. It teaches the rules governing the flow of a direct current in a simple electrical circuit. Preliminary analysis had shown that students had several misunderstandings. Some mistakes were due to everyday life analogies such as the flow of air in pipes, of cars on a road network, of people in the corridors of the underground, etc. or comparing the role of an accumulator with a pump, a lift, or again, comparing electrical resistances with other sources of friction or braking. Much confusion and partial understanding is due to those analogies alone. Other types of error also need to be analysed: errors in applying the rules, such as what each of the accumulator terminals does, spatial visualisation of what form the connections take, what the words used mean, etc.

18. A study along these lines can only be performed, even for a very simple case, after statistical analysis covering a wide and varied population. Such analysis is facilitated by monitoring the package to be produced. The resulting package would show the student a few simple circuits and, with the help of appropriate questions, would analyse his thinking patterns. The assessment would be matched with further exercises for the purpose of specifying the student's possibilities or remedying shortcomings.

Section II

COURSEWARE DESIGN

19. In the initial phase of designing courseware, too much attention should not be paid to the technical limitations lest the educator feel restricted by constraints that the computer expert might impose. It is only at the end of this phase of purely education-oriented thinking that what the hardware and the equipment available can and cannot do should be taken into account so that best use can be made of them. It may happen that, because of the technical problems, the courseware has to be modified or the project even abandoned.

20. Before going ahead with designing courseware, it is essential to decide whether information technology will really help or make a contribution towards the desired objectives and to produce a storyboard as a first step in the design process.

a) The Subject of the Courseware

21. The choice of subject is easier when it is a case of meeting a specific requirement, such as training in methods of diagnosis (doctors) or in a particular technique (aeronautics, banking, nuclear power stations), the marking of examinations or achievement tests, research on the learning of reading or writing skills, the production of a complete course (mathematics for 12 year olds, etc.), the application of the LOGO language, interactive interrogation of a databank, etc. Very often, this choice is the result of a sudden idea (local needs or circumstances) in which case the best solution is to follow the advice contained in an author's guide for that particular educational level and see what courseware has already been produced for similar subjects or approaches.

b) Target Audience

22. One of the advantages of CAI is that instruction is individual. The instructional dialogue will depend on the target group, i.e. whether they are children or adults, from an enlightened background or not, with special problems (handicapped, late starters, lonely misfits or delinquents, unemployed, etc.). Not only may the dialogue need to be different, but also the approach. If the courseware is intended for different groups, different pre-tests will help to orientate the subsequent development of the dialogue and other pre-tests could be used to determine the necessary level of revision.

c) Teaching Objectives

23. The teaching objectives must be carefully and precisely defined. The preliminary requirements and conditions should be specified as well as the methods for observing whether the objectives have been achieved. Here is an example given by two French chemists, R. Luft and A. Puill:

> "Confronted with a three-dimensional model of a molecular structure or its conventional graphic representation, the learner must be able to:
>
> -- Analyse methodically the spatial distribution of the atoms;
>
> -- Determine the symmetry group to which it belongs;
>
> -- Deduce the chirality or non-chirality of the molecule and the possible existence of a rotatory property."

24. In creating this particular courseware package, the necessary parameters were:

-- The spatial distribution of the orbital fields;

-- The conventional methods of representing molecules.

Self-evaluation courseware on this subject would also need to incorporate, in addition to concepts in chemistry, different concepts on operators and symmetry groups.

d) Structuring the Subject Matter

25. The author will need to determine the different stages the student has to be taken through in order to reach the desired objectives. This information, together with what the author has already gathered, will enable him to divide up the courseware into separate sub-assemblies, each designed to impart or test one (or possibly more) of the stated teaching objectives. Each sub-assembly may involve the use of particular teaching methods and strategies. Certain of them performing the same function can be designed to suit different target groups or the choice would depend on certain criteria, including individual student preference.

e) Teaching Tactics

26. The educational dialogue can be made more or less open-ended (multiple choice or open questions). The analysis of answers to questions in a numeric or algebraic form can uncover and even correct some revealing errors. Spelling mistakes and certain typing errors can be pointed out and corrected. Certain exercises involving figures, letters or series of characters can be generated in a random manner. This presupposes that the author has a list of the appropriate instructional functions. The LOGO language (apart from its educative character) is a way of learning geometry or the flow paths in a branching structure (grammar, linguistics, etc.).

f) Teaching Strategies

27. In many cases, the literature will define several strategies: for example, the author's guide put out by CONDUIT (consortium of universities in the United States) lists:

-- Drill and practice;

-- Computer-directed dialogue;

-- Student-directed dialogue;

-- Data analysis;

-- Problem solving;

-- Simulation;

-- Model building.

28. Others may envisage a "Socratic dialogue", a random walk through correlated concepts, intelligent problem-solving employing the methods of artificial intelligence used also in expert diagnosis systems. The definitions could be modified in the light of the tasks required of the student.

g) Overall Teaching Strategy

29. Authors must develop sub-assemblies which can bring different strategies into play. They must arrange the linkage between these modules in relation to the characteristics or wishes of the student and taking into account the different responses supplied by the student himself or by others. The overall teaching strategy can be defined as the different activities proposed to or imposed on the student, i.e. observe, recognise, rediscover, analyse, associate, identify, assimilate, deduce, apply, etc. It defines what assistance is provided and what initiatives are left to the student. It incorporates the possibility of tests, checks and conditional branching. It must take into account the likely reactions of the student to different methods of presentation and prepare the details of the educational follow-up (see Section IX) and, lastly, it must enable the scenario to be written making use of the different communication terminals (see para. 40: courseware production studios).

h) Style

30. The style is not the same as for a written or oral course. It is not unlike certain types of audio-visual presentations with the addition of interactivity. Interactivity requires short, specific and clear messages. Key points, therefore, must be highlighted. The student must be made to feel at ease and, accordingly, told clearly what is expected of him and what progress he is making. Where immediate interaction is not required, information can be supplied in a written or audio-visual form already used in education, e.g. supporting documents, film clips, sound recordings, etc.

Generally it is useful to make sure that the different parts of the courseware are comprehensible by testing it on other teachers or students, after warning them that it is still on the drawing board.

g) Pedagogical Portability

31. The author of a courseware package is faced with problems that are similar to and as diverse as those facing other designers:

- The author of a written lesson must be capable of explaining his intentions in the form of a plan and a written summary;
- The author of a play may wish to add certain stage directions for the sake of clarity;
- A composer must be allowed to specify what he wants from the various instruments of the orchestra;
- A film or television producer must be able to describe his scenarios; and
- A ballet-master to find a way of representing symbolically the movements and gestures of the various dancers.

32. If two authors are to be able to discuss a courseware package independently of its transcription on a computer, they need to be able to call on certain conventions. This is particularly important when there is no description of the variables or the implicit procedures, e.g. format types, permitted response time and length, loop functions, processing of actions, processing of modules, list of permissable separators for each type of analysis, messages related to certain requests, etc. (reference to the glossaries in Annexes 2 and 3 may make this clearer).

33. It would perhaps be worthwhile to formulate a methodology for producing courseware (even if this were incomplete) which could be adopted as an international standard, but leaving open all the possibilities that authors might require. It would be useful to examine the potential of the CODEVTEL Model (not originally intended for CAI) developed by the ITU (International Telecommunications Union) in Geneva and approved by Member States for training their postal and telecommunications staff. The Quebec Department of Education, following a two and a half year study, proposed three guidelines between February 1982 and March 1983: Guide for Education package assessment; tools for self-assessment of education packages in course of production, and an assessment grid. Converging efforts in the various countries suggest the possibility of international standards jointly arrived at but in no way impinging upon the cultural identity of the individual country.

Section III

IMPLEMENTING QUALITY COURSEWARE

34. Exemplary courseware has been produced even with the limited set of software tools and hardware environments available at present. For example, courses in genetics and chemistry developed at the University of Illinois are excellent. Like many other appealing items in the present stock of courseware, these lesson sequences combine graphics with clever simulations to create lively "mini-worlds" which the student can explore in a variety of sensory modalities. Several lessons explaining basic numerical concepts to very young children, which make excellent use of the touch-sensitivity of some of the terminals, are also noteworthy. Prof. A. Bork of the University of California at Irvine has also exploited the combination of graphics and simulation to produce some particularly appealing material for introductory physics instruction. Far more elaborate simulations, some making use of highly specialised computer-driven optical systems capable of duplicating the appearance of landing strips seen from various approach angles and in various lighting conditions, have been used to produce spectacular civilian and military pilot training systems. Industrial firms have produced much training material in computer-driven videodisc formats. At a more rudimentary level of capability, first-rate drill-and-practice material for elementary arithmetic has been produced by Patrick Suppes' organisation. But, in spite of these and numerous other bright spots, the general level of presently available courseware is low.

35. At present, courseware is implemented largely by "amateurs", e.g. by middle-school teachers or university professors, experts in some educational subject area, but new to the computer medium and generally unable to bring any special artistic concept of graphic ability to the challenging compositions that they undertake. Publishing firms are also becoming interested in the field and are groping for a definition of their role, but have not yet become active on any significant scale, besides which they are accustomed to function more as marketing agents for individual authors than as high-spending producers in the "Hollywood" style that CAI will demand. In a few cases, e.g. Queensland and South Australia, Belgium, Canada, Finland, France and the United Kingdom, some educational courseware is being produced by government bodies, actuated by medium-term considerations and able to make larger investments. Attention must be drawn to the particularly elaborate call for tenders by Ontario Province as part of an ambitious project. But this is still uncommon and in small volume. Only a fraction of the courseware presently available is produced by commercial enterprises able to focus the skills of larger and more expert teams. Moreover, the present efforts of

commercial teams are sharply constrained by medium-term marketing considerations, e.g. the necessity of limiting courseware to what is able to run on the smallest and least expensive of today's home computers.

36. Consequently, most present educational courseware is all too often unexciting, in this regard falling far short of the instructional style that the new technology affords, whose characteristic flavour is still far more visible in video games than in most CAI materials. The mediocre character of presently available materials is reflected in remarks gathered in the OECD survey (CERI/NT/84.02) of new information technologies activities in various Member countries. For example, the Canadian response to this survey notes that: "The quality of currently available courseware is generally inadequate. The general provincial consensus would characterise available courseware as poor or spotty, with only one province rating materials of fair to excellent." The United States response states more flatly that: "The quality of presently available courseware is generally poor." However, a few packages, produced with modest resources, mentioned in the preface, are widely regarded with approval, which shows that the interactive computer dialogue method is already yielding worthwhile results.

37. Vastly better material can be produced, but it should be obvious from the examples presented in Section I, paragraphs 13 to 18 that composition of quality packages will involve the combination of many talents. To choose the points of emphasis and the key pedagogical approaches around which a lesson or course will revolve clearly requires a scholar deeply versed in the subject to be presented, who must also be a talented and sensitive teacher, aware of many possible lines of presentation, and who is able to select the presentation best adapted to the CAI medium. These academic skills must be combined with the skills of graphic designers, with the image-oriented, "filmic" skills of the motion picture director, and with much programming expertise, ranging from a knowledge of symbolic manipulation algorithms to video game design. Actors able to read passages of text with dramatic emphasis will also be needed, and film clips illustrating significant moments in history and recording important scientific experiments will have to be either collected or produced. In some cases, elaborate graphic animations will be the most effective way of making a pedagogical point, so the services of animation studios will be needed.

38. It is clear that production of material of this complexity will resemble the activities of a television or Hollywood film studio more than it resembles text-book production -- a cottage industry by comparison. The kind of person around whom such production will revolve will be a director-like figure, i.e. a talented co-ordinator able to think in media terms, rather than academic. Subject-area scholars will play something like the role that writers play in Hollywood, namely they will generate skeletal, first phase conceptual structures, whose realisation will then require much larger groups with different abilities. The organisation of programmers, animators, and cinema talents which the United States motion picture firm Lucasfilms has built up to carry forward their "Star Wars" series of films shows approximately what will be needed.

39. The production of high quality courseware requires a detailed analysis of the teaching process, which in turn implies formulating precise definitions as regards the structure of courseware:

i) A courseware package is a self-contained teaching package for use on a CAI computer system and designed to achieve an overall educational objective. A courseware package generally consists of a structured set of *dialogues* which can be arranged in different ways. In particular, the teacher using such material can modify the linkage between the dialogues;

ii) A *dialogue* is the smallest coherent teaching unit that can be presented to a student in order to achieve a particular educational objective. A dialogue is an indivisible sub-assembly of a courseware package;

iii) A *scene* is the organised combination of elementary informative messages for their student. A scene makes use of different sources of information: visual, sound, audio-visual;

iv) An *interactive unit* is the set of activities making up a student/system interaction decided by the author, i.e., an output of information or a question, reception of inputs from the student, differentiation between question and response, analysis of the response, presentation of the relevant comments;

v) The set of activities enabling there to be an exchange with the student forms the *educational situation* (e.g. the combination of interactive units and their related decision unit);

vi) The *environment* is the set of instantly accessible data for carrying on the dialogue and monitoring progress. These data are up-dated by the system automatically or at the author's request during the use of the CAI system by the student. The data are used to monitor the dialogues, the courseware and the students, so there are, in fact, three environments: dialogue, courseware and student environments;

vii) The *decision unit*, following a calculation involving the dialogue environment in particular, decides on the next step in the procedure (e.g. the next interactive unit);

viii) The *link unit* is attached to a dialogue and specifies the conditions for moving on to further dialogues, as the environment requires.

40. Studios capable of creating quality courseware need to possess audio-visual facilities like those described (see para. 31) and a stock of educational modules on which authors can draw to avoid having to create each courseware package from scratch or remake commonly used graphics (e.g. measuring instruments, everyday objects, maps, diagrams). The following section discusses the features of (a) the hardware and (b) the software required for computer-aided instruction.

Section IV

HARDWARE

CAI Hardware and Cost Trends

The principal "hardware" elements of future CAI systems will be as follows:

a) Processors

41. For these, the basic "computers" which will supply basic computational power to the CAI systems we envisage, the situation is very favourable. The power of a computer is conventionally measured in standard "MIPS" (millions of arithmetic instructions per second). Typical inexpensive personal computers currently in use supply about 1/10 MIP of computing power. The new generation of 32-bit microprocessors rate at about 1/2 MIP. Other microprocessor chips, now in earlier stages of development, should attain computing rates of 5-10 MIPS by the end of the decade. This should make computers costing a few hundred dollars, roughly as powerful as present scientific computers, widely available by 1990, when they will no longer be the most expensive ingredient in an effective system.

b) High-speed Memory

42. In present technology, the data which computers manipulate, select, rearrange, and display is stored on media having one of two radically different characteristics. Data items, for example numbers used in internal calculations to produce graphic output, which must be available within one or two high-speed computational cycles, i.e. within a millionth of a second or less, are stored on integrated-circuit "memory chips". Other data, for which access delays of 1/10 second are tolerable, is held on rotating storage discs, which resemble ordinary long-playing records but which rotate faster and on which information being recorded magnetically can be erased or stored.

43. The amount of high-speed memory available in a computing system affects its performance significantly. If all of the programs and data needed by the computer can be held in high-speed electronic memory, programming the computer is simplified considerably. If, in contrast, high-speed memory is in short supply, programming is seriously complicated by the need to use more intricate, compressed representations of necessary data, and by the need to move fragments of program and data back and forth between high-speed and bulk memory. Faced with this technical challenge, programmers will cut back on the level of external function which they attempt to supply, and increased

programming costs will limit the range of software products which become available. The result seen by the end-user will be systems which are either less sophisticated, less lively, or both. Hence the cost of high-speed memory, and the amount of it available for program/data storage, is an important factor determining the adequacy of hardware for CAI use.

44. A second important use of high-speed memory in the CAI context is in the "refresh" memory which store images displayed on a graphic screen. These images are built up as matrices of individual dots ("pixels") of specified intensity and colour. A 512 matrix of dots gives a high quality image, and a 1 000 by 1 000 dot matrix gives an excellent, almost film-quality image. If one character or "byte" (equivalent to two decimal digits) is available per image pixel, half of this data can be used to select one of the 16 intensity levels, and the other half to select one of 16 colours. If two bytes are available per pixel, 16 intensity levels and roughly 4 000 colours become possible. Thus, a graphics screen backed up by 2 million bytes (characters) of data will provide excellent, glossy-magazine quality graphics. If this allotment of memory is doubled, then while a prior image is being displayed, the computer can be writing the next image to be viewed into a behind-the-scenes image memory. Switching between these two images then becomes effectively instantaneous, eliminating the psychological irritation caused by visible manipulation of images while they are being viewed.

45. At present, the manufacturing cost of high-speed memory is about $1 000 per megabyte (1 million characters of storage capacity). This is based on the use of memory chips storing 8 000 characters each, which are currently available for about $3 or $4. Improved chips, storing 32 000 characters each, are about to appear on the market. Before 1990, these should be available at about the present price of the 8 000 character chips, so that high-speed memory should be available at about $250 per megabyte manufacturing cost. The 1990 manufacturing cost of 4 million bytes of memory for the very luxurious graphics environment described above, plus an additional four megabytes of memory for program and data storage, can therefore be estimated as roughly $2 000.

c) Bulk Data Storage

46. The bulk data required by an interactive CAI system falls into two principal categories: fixed and variable. Fixed data comprises that mass of recorded text, video, and audio material which the computer driving a CAI system need to retrieve and re-arrange, but not to store in bulk after dynamic re-arrangement. The medium of choice for all this material is digital videodisc.

47. The second bulk data category, variable bulk data, includes student-collected text excerpts, massive intermediate results generated by computer calculations (e.g. "workspaces" of temporarily suspended program runs or simulations), screens full of graphic material held temporarily for later redisplay, dynamically generated audio material held for sub-item selection or replay, etc. This material is best stored on rotating magnetic discs.

48. High quality magnetic storage discs able to hold 20-30 million, characters of recorded information, presently retail for about $5 000. Improvements in recording techniques can be expected to increase this capacity

significantly. By the end of the decade, 200-300 million character discs in the $1 000 to $2 000 price range should be available. Some technological forecasters in this area are predicting even greater improvement in storage density, based on the use of circuit techniques, which might possibly increase the amount of information stored on a disc by factors as large as 100. This will provide variable bulk data storage capacity adequate to CAI system requirements.

49. Videodisc already provides an enormous capability for storing fixed data. Laser videodiscs of the kind recently introduced by Philips, RCA, Sony, Pioneer and various other manufacturers store roughly 10 billion characters of information, equivalent to roughly 5 million pages of printed information, 200 hours of high quality audio, or 50 000 video frames (one hour of live video). Technological improvements over the next decade may increase these already very great capacities by a factor of 10. The cost of individual disc manufacture is somewhere around $5, and quality computer-controlled players are already available for between $500 and $1 000.

50. Future CAI material will in all likelihood be stored on videodiscs, several lessons being stored on each disc. The principal constraint on the number of lessons held on a given disc is clearly the number of minutes of live video required: printed text and computer programs are trivial in comparison. Hence it is possible to store large amounts of supplementary reference material on a disc, provided that only still images, without moving video, are used in these supplementary sections. For example, a student in our hypothetical world history course can be offered full texts of all the ancient authors quoted, biographies and portraits of the historical figures cited, additional maps, pictures of Roman military equipment, etc., all of which can easily by stored on the disc which holds his history lesson. As storage capacity rises towards ten hours of video per disc, it will be possible to store entire courses on no more than a dozen discs.

d) Display Terminals

51. High quality colour display terminals are currently available for $400 to $600. This is already a mass-production price, and cannot be expected to fall significantly over the period we consider. Terminal prices should be largely independent of the resolution provided (given that we count the principal cost associated with higher resolution, namely the larger refresh memory required, separately). Touch sensitivity is not at present a standard terminal feature, but it can easily be provided, e.g. by installing rows of light-emitting diodes and matching receptors around the edges of a terminal's screen, and should add little to the quoted price of a terminal.

e) Audio Output

52. A CAI system can make effective use of two principal forms of audio output:

i) Pre-recorded music and speech

As much of this material as is likely to be needed can be held on videodisc and selected for playback under computer control.

ii) Computer-generated speech

Speech of this kind is generated by transmitting text, possibly written in some special phonetic alphabet, to a speech-generating device which expands it into a standard audio signal. This involves application of some form of "pronunciation algorithm", which uses rules of context to fill in details of the audio signal pronounced. This level of detail includes customary elisions and transition patterns which are not explicit in the text supplied. To be done well, such "phonemic expansion" requires a small data base representing various "exception rules" of pronunciation. A high-quality speech generator will also handle inflections, allow emphasis, etc. A speech generator of this quality would currently cost several thousand dollars, but it should not be hard to reduce the signal generator and other circuitry required for high-quality computer speech to a small number of chips, which can be manufactured for well under $100.

53. The technology used for speech generation should also support production of computer-generated music, making elaborate orchestral effects available to the courseware designer, at little or no additional cost.

54. The above list of peripherals is not exhaustive. A computer is usually linked to a printer and sometimes to a plotter. Input may be by keyboard, tablet, touch screen, mouse, joy-stick or even voice analyser.

Portability Between Different Hardware

55. It is important to ensure courseware portability as between different hardware of comparable performance. Compatability of the interfaces is essential and account must be taken of the numerous differences there are:

- Type of keyboard: QWERTY or AZERTY, accents, function keys;
- Type of information medium: size, sector pattern, density;
- Type of screen: number of lines and columns, character definition (semi-graphic, alphanumeric), colour, graphic functions;
- Type of connection to peripherals: series/parallel, V 24 socket, Peritel socket;
- Type of central processor.

56. Portability is possible between microcomputers operating with the same microprocessors but this is not always the case. Moreover, there are currently four different levels of CAI system in use:

i) Videotex terminals;

ii) Personal microcomputers with viewer, small printer and cassette recorder;

iii) Microcomputers with larger peripherals;

iv) Minicomputers or mainframe computers.

57. Courseware authors should use the largest-capacity configurations providing access to a number of databanks. The courseware itself should be operated on a high level configuration comprising the microcomputers and terminals described above. However, the lack of uniformity between processors and peripherals creates difficult problems of portability and compatibility. The situation becomes even more complicated if it is wished to run a simplified version of the courseware on less sophisticated configurations.

58. The functions usable for the instructional dialogue are insufficient in the case of videotex and of a fairly low order in the case of 8-bit microcomputers, but the situation is changing rapidly and the above four levels could well be reduced to two. Videotex systems are starting to use microcomputers as their "intelligent" terminals and microcomputers now incorporate 16 and even 32-bit processors.

59. From the user's point of view, the best solution will in many cases be to have, like the authors, microcomputers connectable to more powerful computers so as to:

i) Have no difficulty in using the latest courseware versions;

ii) Be able to make use of ancillary resources (operations requiring substantial computing power, vast arrays of data requiring frequent updating);

iii) Be able to consolidate the results of sessions and thereby improve courseware by the fine analysis of these results;

iv) Be able to consult and try out existing courseware packages.

Section V

SOFTWARE

60. Courseware must:

- Be easily modifiable (corrections and essential updating: a courseware package is a "live" product);
- Be adaptable for different audiences (large target audience for cost-effectiveness reasons). A package can be amortized just as well over time as over users;
- Continue to function satisfactorily after modifications (there must be absolutely no need for debugging);
- Be "readable" by the instructor who proposes to use it.

61. The courseware is controlled by a computer program -- the "software". The software controls: I. THE QUESTION AND ANSWER SEQUENCES and II. THEIR PRESENTATION VIA THE AUDIO-VISUAL ENVIRONMENT. It may be written either in a general purpose and, if possible, standardised computer language (e.g. PASCAL, MT) or with the aid of an author-system involving specialised editors and a quasi-natural language form.

62. It should be noted that the question concerning the precise functional capabilities most necessary for the composer of courseware at various levels of sophistication and the manner in which these can most adequately be provided is the subject of active discussion among technical experts in this area. Although many would agree with the stress which the present report lays on development of an authoring system, A. Bork, however, has successfully developed first-rate packages using standard-general-purpose languages like FORTRAN and PASCAL, and would maintain that no specialised language is necessary. On the other hand, many authoring systems are in current use. Since all other major fields of computer application, e.g. commercial programming, word processing, mechanical engineering, simulation etc. have developed languaged and tools to facilitate their activities and make them more readily accessible, the authors of the present report expect the same to be true of the courseware writing field as it grows.

63. It should be noted that few of the capabilities which have been described as essential for courseware writing, e.g. animation, video output, computer-generated speech, input from a touch-sensitive screen, are either

provided in general-purpose languages such as BASIC, PASCAL, or LOGO, or relevant to these languages. Note also the distinction between courseware writing languages devised for use by the authors of courseware (e.g. educators or programming technicians working with them) and languages for student use devised to facilitate instruction in programming and computer science. LOGO is a successful example of languages of this latter type, and has attained real educational success by packaging such important concepts as procedure construction and manipulation of geometric rather than numeric concepts in a form accessible to the beginning student. Though important in their own right, these languages, when seen from the point of view of the present report, merely illustrate the general importance of proper programming tools, and can be regarded only as specialised instructional facilities, which need to be made available for invocation by courseware authors within the framework provided by a generalised authoring language.

I. CONTROL OF QUESTIONS AND ANSWERS

64. Except in rare cases, therefore, authors of educational material should not attempt to "program" but should define their intentions and provide instructions in the form of a description of the "dialogue structure", indicating general operations for controlling the interaction with the student: analysis of messages (replies or requests). In this sense, therefore, high level instructions of this kind, which initiate complete and specific CAI operating sequences, are not covered by standard algorithmic programming languages but instead are new modes of expression more akin to statements than instructions. These modes of expression used in some "author languages" are gaining ground and are clearly one, if not the only, way of overcoming the problems of computerising the courseware developed by teachers.

65. Potential authors should have access to a "dialogue bank" from which they can extract material and thus not have to compose each courseware package from scratch. By the same token, banks of educational data such as illustrations, exercises, etc. also need to be set up.

66. Compiling these "courseware banks" means, of course, first of all developing a general methodology; without going as far as standardisation, it is important to select a minimum number of basic tools for use by every author and to identify the common features in all instructional dialogues irrespective of their particular educational strategy. This is in line with the general direction of current trends widely recognised as being valid in other computer fields -- that is to say:

i) To provide designers with software tools that operate high level logic models;

ii) To encourage designers to structure their material (in their own and the user's interest).

67. It is therefore clear that, for CAI purposes, computer experts have to create a whole architecture of resources. Producing such application systems is obviously helped by the progress made in software engineering and the experience acquired in areas such as computer-aided design and data bases.

However, this know-how and these techniques are not sufficient to satisfy all identified requirements for three reasons:

68. The first is that, unlike what is usually the case in other areas, the end-users (i.e. the "students" in the broadest sense of the term) can be anyone at all, which means in particular that interactive sequences must be in natural language.

69. A second reason is the fact that the system has to communicate with highly differing categories of user. Apart from the students who are the main category, there are also the authors of the courseware and the teachers who use it. Even if the same person combines these last two functions, these are two quite distinct roles with quite separate requirements as regards the system's resources.

70. The third reason is the extreme variety of resources which need to be deployed simultaneously since education, by definition, concerns every discipline, every level and every technique. Just the incorporation of this vast range of resources, which is constantly growing not only in size but also in variety, is in itself a major problem.

71. The systems that have been, or are being, produced have already brought improvements in software in a number of different directions, which can be classified in terms of two main problem areas:

a) Problems of natural language communication (man/machine dialogue); and

b) Problems of constructing and manipulating complex objects (composition and creative operations in a conversational mode).

A. Communication: Man-machine Dialogue

a) Student-machine Dialogue

72. As we have seen, the CAI audience is extremely varied in age, socio-cultural background etc. Using a computer terminal has to resemble as closely as possible a normal interchange between individuals, even if this interchange involves the use of audio-visual, graphic or other types of aids; there can be no question of having to learn complex and arcane procedures, as might reasonably be expected of specialised staff (computer experts or others) working on a screen. In fact, the tendency now is to employ a "user-friendly" approach even in the case of specialists -- in other words, to make the user at ease by ensuring that he is addressed in the form of complete, plain-language messages that accurately describe the situation and that the computer shows a considerable capacity for "understanding" the messages it receives from the user. For instance, "menus" are increasingly common, which unquestionably make life easier in many simple cases. As far as CAI is concerned, however, this solution is totally inadequate as a means of expression for the student, short of getting bogged down in "multiple choices".

73. Analysis of student semantic responses is an area of great importance. Student responses typed at a terminal can be regarded either as character strings or as word sequences. Some systems make use of these to analyse numerical, algebraic or textual answers:

-- Analysis of numerical answers may accept a certain percentage of deviation from the exact value and interpret unit changes;

-- Algebraic analysis accepts different but equivalent forms of an expression;

-- Textual analysis recognises words, even when typed if required (upper/lower case, presence or absence of additional spacing, incorrect punctuation, etc.).

Unless an exact match is specified, words will match if a standard spelling-error algorithm judges them to resemble each other closely enough to be regarded as misspellings of each other. A combination of words consists of a given sequence of words, including "ignorable" words which may appear in the student's input text but will be omitted in the assembly operation.

74. A word pattern consists of a specified sequence of words, together with a set of "ignorable" words which can appear in the student input but will be ignored by the matching process. The individual items in the Q sequence are actually sets of logically equivalent words, any one of which is acceptable in a given position. The match operation can specify either that all words in the student input must appear in the pattern to which the input is matched (full match) or that a subset of the input must match the pattern (subset match). It is also possible to specify either ordered match (in which case words must appear in the student input in the same order in which they appear in the pattern being matched) or unordered match (in which case the elements of the pattern can be arbitrarily permuted without disturbing the match).

75. All this is good as far as it goes, but deeper methods are urgently required. Current research in computer analysis of natural language is steadily extending the ability of computer programs to deal with unrestricted natural language input. However, this ability is still highly imperfect, and may not be usable at all until it becomes entirely solid. Even if a computer handles 90 per cent of a student's natural language inputs adequately, bizarre reactions to 10 per cent of these inputs, or even inability to produce any reaction, may create an unnerving pedagogical environment, which often forces the CAI designer to prefer multiple-choice inputs chosen from a pre-restricted menu. For this reason, and also because of the presently very high computational cost of natural language input, we can expect the use of such input in courseware to develop slowly.

76. In the case of a narrow subject matter, however, it is possible to allow the student to express himself naturally or, at least, substantially reduce the constraints and virtually eliminate input instructions: in such cases, knowledge of the context should make it possible at any point to analyse accurately and rapidly the input from the student (e.g. with less than 1 per cent misinterpreted responses). This does, however, mean compiling a fairly precise typology of situations and meaningful "objects" (type and form). While it is always the author's responsibility to define exactly what he is looking for in the student's input, it is the program-writer's responsibility to work out and provide the author with:

i) High powered facilities for describing research "models", which are easy to write and read back;

ii) A limited number of well-differentiated, high-performance analyser modules (with a message analysis time of about one second).

77. Fundamentally, these problems are not confined solely to CAI, but in other data processing areas these vocabulary limitations and constraints (resulting from the use of technical jargon) have not so far proved the drawback they present in the case of education, where the process is more one of "constructing" than "designating" and where the messages processed cover a vast semantic field.

78. The lessons of experience to date highlight the need:

i) To clearly differentiate between message "production" and message "recognition"; what interests most the designer of a dialogue is the meaning of the student's input, not the way this input is produced: for example, the student can indicate the co-ordinates of a point by typing numbers on a keyboard, by positioning crosslines on the screen, by moving a cursor by means of control keys, by indicating the point on the screen with a light pen, by speaking the numbers into a microphone, etc.; the author, on the other hand, has to identify the point in his own logic design, e.g. a set of two numerical co-ordinates; clearly therefore standard interfaces are needed capable of feeding the analyser selected by the author from any input from the student;

ii) To design separate analysers depending on the type of object sought in the student's input; different processing is required for identifying textual expressions, numerical expressions, formulae, etc.; each object has its own structure and its own coding.

b) Teacher/machine Dialogue

79. In this case, the problem is one of specific "editors" which enable the teacher to define the content of the dialogue or to modify it. Here again, the need is for clear differentiation of the objects being dealt with: text (character string), screen displayed text, diagrams (graphics), etc. and the combination of these objects.

B. Construction and Manipulation of Complex Objects

a) Creation of Courseware

80. A courseware package will inevitably be a complex object if the author's intention is to create a product which is open-ended and coherent. It is essential therefore for the author to be able to design his software as a highly structured object, with each section or sub-section as independent as possible so that it can be re-used or modified. For this reason, a courseware package should take the form of a series of "dialogues" with a conditional linkage so as to allow selection if individual flow patterns. It will thus be very easy for a teacher to adapt an existing courseware package:

i) By simply rearranging the dialogues in the courseware;

ii) By deleting dialogues or adding other existing dialogues;

iii) By incorporating a dialogue of his own composition or by substituting it for an existing dialogue.

In order to do this, a standard mode of expression should enable the course of events to be described by means of a "flow chart" indicating what is happening at any given moment. Decisions will be taken in the light not only of local requirements but also of the "checks" prescribed by the author.

b) Processing of Instructional Inputs

81. The educational items are regarded as manipulable (selection, combining, sorting, looking for correlations, etc.). Such operations can be preset once the usual presentation problems (variable automatic formatting, summarising, etc.) have been solved.

II. MANAGEMENT OF THE AUDIO-VISUAL ENVIRONMENT

82. The CAI environment described in the preceding pages combines graphics, voice output, music, video, major textual and image data bases, and very sophisticated software. To facilitate the creation of courseware of this flexibility, authoring systems which make many capabilities available to the courseware designer will be required. The list of desirable capabilities is long and still being worked out, in an environment of constantly changing technologies and costs. Although this makes definitive statement of the required capabilities difficult, we can at least list some of the facilities most likely to prove broadly useful. These include: two-dimensional text output, in a variety of alphabets, fonts, letter sizes, and character orientations; two dimensional graphic representation of three-dimensional figures; animation, and in particular multiple animated "sprites" of the kind used by video-game designers; video output in still-frame and continuous-play modes; electronically generated audio-signals; high-quality computer-generated speech; audio playback of narration and music. (Note that the development of high-power graphic chips may make it feasible to use very high quality 3-D "syntavision" images.) In addition, an effective CAI language should support input from a touch-sensitive screen, and from various kinds of "tablets", "joysticks" and "mice", which can be used to pass graphic information to a computer. These facilities should support various useful forms of "rubber banding", i.e. for drawing lines and other figures which stretch and shrink dynamically as a student's finger moves on a touch-sensitive screen. In addition, powerful response-analysis routines and general-purpose computational facilities will be required.

83. In regard to the technical problems of implementing first-rate courseware rapidly and inexpensively, the appropriate tool is a powerful, transportable, standardized, very high-level CAI language that is easy to use. Even though current CAI authoring languages suggest features desirable for such a language, none of them are well-organised or transportable enough to serve as such a language without very major changes. Experimental work on such a tool, pursued in an environment providing first-rate hardware, should

be regarded as a main developmental priority over the next few years. The following paragraphs comment on some of the facilities which such a language will have to support:

a) Powerful General-purpose Computational Facilities

84. Courseware will occasionally need to make calculations of the sort supported by general-purpose algorithmic languages, for which reason an authoring language should make all the facilities of a powerful algorithmic language available. These should include flexible string manipulation and analysis operators, pattern-analysis mechanisms, operators facilitating use of general tables and maps, and a capability for handling very general composite objects, for example, internal representations of the shapes of complex geometric bodies. New types of objects should be definable by the courseware writer. Since some of the operations used in CAI languages will have numerous inputs, many of which remain constant over several successive invocations of the operation, partial pre-processing of these inputs is a useful facility. Since simulation-based lessons can be expected to be common, simulation-oriented parallelism, i.e. the ability to define various semi-independent event streams which the computer can push forward more or less simultaneously, is a semantic facility which is important to provide. Finally, since it is so powerful a tool for response analysis, generalised backtracking, i.e. the ability to carry out computational activities provisionally but to eliminate all their effects when and if they prove fruitless, is a desirable semantic mechanism.

85. No existing CAI language fully supports all the facilities listed in the preceeding paragraph, even though a modest general-purpose computational capability is available in all CAI languages.

b) Response Analysis

86. It may be possible to develop inexpensive speech-recognition chips which can deal adequately, with very limited classes of utterances, e.g. "yes", "no", numbers and letters, etc. This could be a valuable adjunct to touch-sensitive screen input, and should be supported by a coursewriting language if and when it becomes available.

c) Various Types of Specialised Editors

87. Here the question is not of improved text-editors, of which a great variety are already available, but of editors which facilitate the composition and manipulation of graphic figures. Valuable design ideas for editing systems of this type can be gleaned from various "electronic paintbrush" systems now available to artists interested in computer graphics.

C. Some Possible Developments for the Future

88. It is worth emphasizing that the preceding discussion of CAI software tools is deliberately humdrum. It emphasizes software facilities that can be developed now, and by intent, ignores many exciting software and courseware possibilities having too large a research component for their immediate

construction to be straightforward. To redress this perhaps overly pragmatic attitude, it is worth describing a few of these more speculative possibilities. Some of these relate to our steadily improving, although still imperfect, ability to process natural language.

89. For example, a natural-language parser might work with grammar, comprehending both the constructions of standard natural language and those of other less "literary" language versions which students tend to use. Sentences in compositions which were not quite grammatical could then be parsed, and trigger either review of the grammatical rules being violated, or paraphrases of the offending sentences which cast them into literary form. (A parser of this sophistication could also work out sentence diagrams for the student's edification.) A somewhat more sophisticated parser might also be capable of detecting common faults of style, e.g. the use of passive constructions where shorter active phrasings are available, and might be able to generate various improved reformulations of a user's sentences for his inspection and possible adoption. Though it would have to operate at a much more sophisticated syntactic level, such a program could be regarded as a syntactic analogue of the spelling-error detection programs that have now become common.

90. A wave of enthusiastic attention is now focusing on so-called expert consultant systems, which attempt to diagnose real-world situations, assigning each such situation to one of a finite number of diagnostic classifications by asking sensibly ordered sequences of questions. It is hoped that systems of this sort will be capable of imitating the investigative model used by human experts closely enough to approximate expert behaviour. If this hope proves justified, it may also prove possible to use these systems to compare expert behaviour with novice behaviour, and e.g. to automatically critique students in analytical chemistry or medical diagnosis classes for asking questions that are probably irrelevent, or for attempting laboratory manipulations which an expert would refect as being unlikely to succeed. These intriguing possibilities relate to the broader question of the extent to which CAI systems can develop valid models of a student's skill inventory and cognitive biases. To do this will obviously not be easy, but to the extent that such an attempt succeeds, CAI systems will come to behave like sophisticated, infinitely patient tutors (cf. Section X, artificial intelligence, para. 121).

D. Courseware Portability

91. Some courseware can only be operated on hardware configurations designed specifically for CAI and are therefore not portable to other configurations. The cost of producing satisfactory courseware currently ranges between $10 000 and $50 000 per hour. This cost can be substantially reduced by authoring systems linked to courseware banks. It can also increase if the services of television or computer animation studios have to be used. It is important that quality courseware designed for a wide range of users should be compatible with the different types of hardware they may have. Mention has already been made of the benefits to be derived from ensuring the educational portability of software as well as its portability on different terminals. A further requirement is that the controlling software should also be portable. Yet another prerequisite (to be considered later in this paper) is that courseware follow-up should also be portable, which in turn means portability of the relevant software.

92. Certain countries rely solely on hardware for portability: Alberta,

Canada has chosen Apple; Great Britain has chosen the RML 380Z, the BBC Micro and the Sinclair ZX Spectrum; some US States and Canadian provinces have gone for PLATO hooked up to a CDC computer or on its own with the micro-PLATO. Another way of ensuring software portability is to write the courseware in a computer language such as BASIC or Pascal. However, there are several versions of these languages, which depend, what is more, on the type of hardware that supports them. Some countries have adopted a particular version: Denmark and Ireland, for example, use COMAL 80. An attempt has been made to standardize some of these languages (e.g. Pascal USCD, the choice of several states in Australia). But this does represent a considerable advance on the proliferating versions of BASIC (not to mention its graphics and sound extensions). International cooperation might be useful in standardizing at least the core of a number of computer languages useful for CAI. This could lead on to some degree of hardware standardization.

93. However, in this case, portability can be incorporated at the level of the Operating System, e.g. CP/M or MS/DOS which then become virtual standards for microcomputers. Failing this, translations are made, with varying degrees of success, from one language to another. Run-time hardware interpreters and emulators represent partial solutions more in use. It is anticipated that this rapidly developing technology will evolve new solutions in future. It is noticeable in fact that the manufacturers work to a limited number of standards. Until then, rewriting software as necessary is likely to be the solution for software developers.

94. A different method is to represent the courseware as data for processing. The data for CAI a lesson may need reformatting, but this is considerably easier than if each lesson were a program requiring translation to a new programming language or conversion to a new computer system (McDonnell Douglas).

95. Another solution is to use a standardized internal representation at computer level. One instance is the DIANE Project in France. Portability is ensured by using some 150 standardized capabilities to incorporate the educational content. The internal representation includes no implicit instructions, imposes no teaching strategy and will support any desired extension. It therefore guarantees portability. Conversely, it makes it harder for the author to express material directly (and does not guarantee educational portability). There are two independent methods of correcting that defect: either to use special purpose editors for amendment, output and folllow-up or to use a language form in which the author can describe his data within a structure in which he is no longer obliged fully to describe the usual instructions. Those instructions are specified as part of the teaching strategy freely chosen by the author.

Section VI

DISTRIBUTION OF SOFTWARE AND COURSEWARE

96. The distribution of courseware has to contend with all the problems of distributing written documents and audio-visual sequences with, in addition, the problem of distributing the software which manages this environment and the question and answers sequences. There are several methods:

a) Distribution by Network Transmission

97. Software can be distributed by dispatching the media on which this is recorded (cassettes, diskette, tape, PROMS, videodisc). However, software is now frequently distributed by network transmission, with the result that there is a temptation to arrange for distribution a substantial proportion of the courseware data by the same method. It is important to be able to do this for at least the more active parts of the courseware, i.e. the dialogue logic and courseware follow-up (see Section IX). This method of distribution is also worth considering when the courseware makes use of databanks. Sound, text, graphics and software can be transmitted over the ordinary telephone network (switched network) or more rapidly and more reliably by special high through-put networks (coaxial cables, optical fibres, etc.) Naturally, here again there are problems of portability:

-- Compatability of the different media;

-- Teletype compatability if the telex network is used;

-- Standard interface fitting the network (e.g. interface X 25).

b) Distribution by the State Education Services

98. In many cases, users in the state education sector have taken steps to organise the distribution of courseware, usually independently of the already established distribution channels for educational audio-visual material. In the United States, the universities consortium (CONDUIT) distributes post-secondary level courseware. In Australia, most of the states have a special service which goes under a variety of names, e.g. Educational Media Service, Educational Technology Centre, Education Department Computer Centre, and Computing Branch of the Education Department. In Canada, distribution is handled by the department of education in a number of provinces (Alberta,

British Columbia, Ontario and Quebec, in particular) and some courseware packages are distributed via the Telidon videotex system. In the United Kingdom, distribution is organised by the MEP (Microelectronics Education Programme) and the SMEP (Scottish MEP) via regional centres. The Council for Educational Technology (CET) and the MEP have set up a central information service called CEDAR (Computers in Education as a Resource). The BBC Computer Literacy Project distributes its own courseware and the BBC has a telesoftware distribution service using Prestel videotex, which can feed courseware into school microcomputers. In France, the education department's computer unit distributes cassettes of courseware produced by teachers. The teaching profession has also set up a freely available mail order service for distributing both the education department's courseware as well as that produced by educational publishers. Distribution has been handicapped by the difficulties involved in making large numbers of copies of diskettes. A number of courseware packages are distributed by the Musée de la Villette via the Teletel videotex system.

c) Distribution by Private Undertakings

99. Educational publishers distribute courseware through their normal distribution channels. Several hundred other firms in the United States and several dozen in Europe produce and distribute courseware which can be run on specific types of microcomputers. In many cases, distribution is handled by microcomputer sales outlets. Shops have been set up similar to "videoshops" but specialising in courseware. Courseware material can also be distributed via the telephone network: in France, Didao-Bordas are planning to distribute 350 hours of courseware ancillaries to school textbooks via Télétel. This courseware can be used on a videotex terminal (or TV screen) or loaded onto a microcomputer. Courseware documentation can be included on the same diskette as the package itself. But if the documentation is voluminous, or needs high-quality layout, it should preferably be printed. The difficulty of reproducing material printed in colour also helps to safeguard the whole package against pirating.

Section VII

PROTECTION OF RIGHTS IN SOFTWARE AND COURSEWARE

100. If the courseware industry flourishes in the manner predicted, it will create major economic interests in a mass of publishable software, visual materials, music and so forth. It will therefore be most important for the relevant legal authorities to establish a framework of statutes and administrative regulations conducive to the active and unobstructed development of this material. The legal issues involved are quite complex, and still not clear, even after many court trials in the United States and Europe. The basic problem is to reconcile two aims: on the one hand, freedom for development of general mathematical or combinatorial principles applicable in many circumstances and to a wide variety of systems, on the other hand, protection for some specific products.

101. This makes it necessary to answer questions such as: when is one computer game, or one graphic display, or one interactive question-answer sequence, close enough to another to constitute an infringement of rights in intellectual property, given that the actual technical embodiments of these materials can vary greatly. Note here that computerised instructional material will partake partly of the character of films, partly of the character of music, partly of the character of a book, and will in part have a highly technical character for which claims of increased efficiency in the execution of previously known procedures will be crucial. It may be claimed, for example, that even though none of the separate elements combined in a program are unique in and of themselves, their combination is unique and hence deserving of protection. Problems of this sort have of course had to be faced in the publishing and film industries. If we create a successful series of detective stories based on a lean pipesmoking detective with a physician companion, and you copy our format changing only the names, can we sue you? Can we sue you if you write new stories involving characters having the same names and attributes? Although long familiar with these questions, the courts will now have to face them in settings much complicated by a wide range of new and extremely plastic technologies.

102. Though this report can of course make no detailed statement concerning this difficult juridical problem, a brief review of legal opinion in these areas will show complexities that the courts have faced in trying to deal with protection of intellectual property embodied in electronic forms ranging from circuits to symbols recorded on magnetic, optical, or other media.

103. Protection of software has been sought through laws governing patents,

copyrights, and trade secrets. However, till very recently patent protection for software has generally been denied, often on the grounds that programs or computer algorithms do not constitute a patentable industrial "process" in the sense of typical patent laws, but are instead more akin, if large and composite, to published literary works for which copyright rather than patent protection is appropriate, or, if succinct and algorithmic, to mathematical formulas, which are not patentable. In particular it has been held that the mere application of a computer to implement a process or procedure previously known but realised in some other form does not constitute a patentable invention.

104. On the other hand, the courts have been reluctant to rule that data having electronic form, for example a microprogram represented by a pattern on a silicon chip, could constitute a literary work ("work of authorship") to which copyright protection could be granted. For example, the Unites States Supreme Court has held that no copyright infringement was created by publication of a perforated roll for an automatic piano which, when operated, exactly reproduced a copyrighted work of sheet music: this on the grounds that the perforated roll was not "in form which others can see and read". Based on this precedent, a similar judgement denying protection was delivered in 1980 in a suit claiming infringement of copyright in regard to a computer chess game. Very recently, however, the United States courts have ruled that computer software, whether it appears on a floppy diskette or is etched on chips, is protected by copyright laws. This decision, delivered in September 1983 in a suit between Apple Computer Company and the Franklin Computer Corporation, contravened Franklin's claim that operating system software embedded in ROM microcode could be copied freely. Nevertheless it must be realised that the protection created by this ruling covers only the copying of fully detailed software, not the imitation of more general graphic strategies, question/response and lesson sequencing patterns, etc. protecting all of which may concern a courseware company as much as or more than detailed code sequences.

105. In regard to protection under legislation governing trade secrets, the problem has arisen as to what exertions are necessary on the part of a company wishing to claim such protection if their claim is to remain valid, and the extent to which such exertions are compatible with a general public interest in the diffusion of technology. Is total nondisclosure of a technique or process a necessary condition for securing trade secret protection? If not, what is the permissible breath of disclosure, e.g. does public viewing of the human-factors content of a graphic system, computer game, or CAI lesson void this type of protection?

106. Action by competent and technologically sophisticated legislative, administrative and juridical bodies is clearly needed to sort out these questions.

107. When a programme is written in a particular language, it is not at present protected if it is reproduced in another language, particularly if it is adapted to another type of hardware. Courseware protection may cover the following four components:

i) The teaching strategy: This is embodied in a flowchart separate from the texts or images presented and represents a considerable programming effort. It is easy to compose a "new" courseware package simply by changing the texts or the images;

ii) The set of dialogues, i.e. all the possible displays included in the courseware;

iii) One particular dialogue, i.e. a modular unit of the courseware -- an indivisible component which forms a whole and which, as such, can be used in another courseware package. Courseware production studios have a bank of such dialogues;

iv) The still images and the supporting documents covered by the ordinary copyright laws.

In the case of these four components, what needs to be considered are laws of appropriation, adaptation and translation.

Section VIII

OBTAINING COARSEWARE

a) Courseware Specifications

108. Catalogues of school textbooks describe them, state for what category of students they are intended and reproduce the table of contents together with several pages of text. These catalogues can be used to select a textbook on a given subject for a particular grade. By contrast, catalogues of scientific films are much more difficult to compile and use -- it is not easy to gauge whether a particular film will in fact be interesting, of the right standard and capable of holding the classes' attention, and to know whether it is self-contained or whether the teacher needs to prepare a suitable introduction. (The Departments of Education of the six provinces of Canada produced a "Joint Provincial Courseware Cataloguing and Indexing Project" in June 1982 in order to define the cataloguing and indexing method having regard to the different information channels.) A catalogue should be laid out differently depending on whether it is aimed at a decision-maker whose task it is to define the measures to be taken to acquire an education package library, or to the classroom user.

109. Courseware catalogues are even more difficult to compile. Perhaps one answer would be to use the CODEVTEL classification (cf. Section II, para 27) amended and amplified to include the details required by the teacher or student, e.g. subject matter, aims, standard, target audience, potential uses, strategies, interactivity etc. It would be desirable to follow some standard model for these specifications.

b) Information on Courseware Quality

110. The customer needs to be protected against misleading advertising. The State of Florida (Senate Bill Section 283-25) insists on a data collection and analysis test before a courseware package may be put on the market. A consumer association evaluates courseware by means of the EPIE (Education Projects Information Exchange) and publishes its findings in an information letter (Microgram).

111. We expect the rapid diffusion of computer equipment to schools and homes to bring increasing masses of courseware onto the educational market. As this happens, the role of agencies able to provide schools and individuals with informed judgements as to the quality of these many offerings will grow.

Some assessments of this kind are already being provided by public authorities and by nationwide organisations of educational computer users like EDUCOM in the United States. Systematic strengthening of organisations of this kind seems desirable, as does the development of international links between various regional and national courseware diffusion and assessment bodies.

112. The function of software reviewers writing in the technical press is growing in importance, e.g. the New York Times now runs a weekly column entitled "Personal Computing" which regularly reviews not only instructional programs, but also word-processing packages, financial planning aids such as VISICALC, data-based systems for personal computers, etc., commenting on their ease of use and general quality. Consumer-oriented computing magazines like BYTE and Personal Computing publish increasingly voluminous material of this same type. Informal user comments on software systems also circulate actively and very rapidly through various electronic "bulletin boards" established within major computer networks such as ARPANET.

113. The Allenbach company publishes "Software Reports" and provides assessments and guidance on choice. These assessments are compiled after consulting teachers, parents, and students and processing their replies on a computer. This material, prepared by authors and distributors, should include a technical specification for the user indicating the subject (level, knowledge required) and also the hardware (peripherals, support operating system) together with a "quality" record dealing with teaching strategy, presentation and follow-up. A simplified representation of the package flow chart for the teacher is highly desirable. These specifications are not the same as the validation records produced from users' experiments.

c) Shopping for Courseware

114. The best way of picking a book is to browse through it, glancing rapidly at a number of pages and stopping whenever something catches the eye or attracts the attention. This is hardly possible in the case of courseware. A few typical extracts from the instructional dialogue and a flowchart describing the teaching strategy provide useful but insufficient information. Preferably, therefore, courseware should be accompanied by descriptive literature designed either for teachers or for students.

115. In Great Britain, the CEDAR Project (Computers in Education as a Resource) has prepared a videotape containing key video sequences from a hundred or so preselected courseware packages. CEDAR circulates various information on English-language courseware and sends it to the fourteen MEP (Microelectronics Education Programme) Regional Centres, where it can be consulted. In the United States CONDUIT produced a magazine called PIPELINE until 1983, and now issues catalogues by subject or computer language. Some packages can be described in a one or two page abstract, with photographs of illustrations and graphics on the display screen.

d) More Detailed Assessment of Courseware

116. The best way of assessing a courseware package is to try it out, but its manifold conditional branchings and the way in which these are decided may

not always be spotted even after several runs on a terminal. One needs to be able to read clearly the corresponding instructions (on the listing or in an accompanying document). This will be simplified if the courseware is written in an authoring language or using a system designed to be easily understood. Users can inspect the courseware packages prepared by the various companies as well as some of those designed for specific microcomputers. This can be done through the manufacturers themselves or their agents in the big distribution centres. Courseware packages can also be examined in the clubs which are springing up in increasing numbers to promote computer applications. Periodic exhibitions, and in time probably also permanent exhibitions, i.e. computer museums, are well worth organising since they make it possible for school officials and individual consumers to gain personal knowledge of the advantages and shortcomings of various courseware packages through comparative inspection of many such systems.

e) Courseware Library

117. For products available in the UK, CEDAR has a bibliographic information service (in a databank and available on microfiches), a library, a set of courseware packages that can be examined on the spot and a series of extracts from courseware material on videotape. It has a telephone enquiry service and runs a CAI training centre. Several countries have similar courseware libraries which should make it possible to arrange an exchange of information and demonstration material. Libraries can soon be expected to offer direct remote access to their courseware banks or at least, to those parts from which the level and the main features can be assessed.

Section IX

EVALUATION, ANALYSIS AND REFINEMENT OF COURSEWARE

118. We have already mentioned several journals and periodicals which publish comments on the quality of particular courseware material. There are, in fact, several dozen such periodicals in the United States, as a result of which a publication has recently been launched with the title "Evaluation of Educational Software: A Guide to Guides". Since most of the criticism in these reviews is fairly subjective, this is not an easy way to get an idea of the qualities and shortcomings of a courseware package. However, one periodical which should be mentioned is Educational Technology to which a number of specialists contribute whose comments -- highly critical on occasion -- are published alongside the author's reply. Since the creation of ENTELEK, the first courseware databank (1965), and as the result of a great deal of effort, it is now possible to assess courseware on the basis of criteria which are as comprehensive and objective as possible. The CONDUIT method of assessment is a particularly good example and a number of systems of evaluation have been modelled on it (e.g. the Quebec Department of Education and the Musée de la Villette in France). The tendency nowadays is to concentrate on criteria whereby the quality of the contribution that the microcomputer makes to the educational process may be measured.

119. As school systems grow more concerned with and dependent upon CAI materials, we can expect the scientific content and professionalism of courseware reviewing to increase. Computerised courses in a given subject area can best be reviewed by professionals able to assess the choice and sequencing of topics, accuracy of explanation and simulation, quality of graphics, flexibility of presentation, and ability to deal adequately with the kind of errors and misappreciations typical of students at a given grade level. Informal review by individual experts and expert panels will be supplemented by formal, statistically monitored experiments, in which courseware is brought into trial use by school classes, including both "typical" classes and classes representing various special educational situations, such as disadvantaged, handicapped, or gifted children. Experiments of this type allow detailed information on student interactions with courseware to be collected. For example, one can measure the number of times courseware meets totally unanticipated student responses, students' speed of response to various questions, the frequency with which optional help sequences are requested, student success with frequent short quizzes, etc. The courseware producer is in the favourable position of an author able to observe minute details of reader reaction to his book.

120. Careful external reviewing, experimental use, and systematic collection of student and teacher response to courseware will allow it to be progressively improved and systematically tailored to a variety of educational and national settings. The ethical rules to be observed here are mentioned in paragraph 12 (iv) above. Provided that the overall structure of a computerised course is sound, portions of the course that are frequently judged to be dull or rigid can be made more lively and flexible by the use of additional graphics, video and audio materials, optional bypasses which allow students to advance more rapidly or along different paths through a lesson, etc. Common student responses which are not handled adequately can be systematically classified and their treatment improved by adding additional response-analysis code. Passages which are found to be too difficult can be supplied with additional explanatory text, diagrams, animations, simulations, and optional "HELP" sequences. We anticipate that many courseware classics suitable for broad national and international use will ultimately emerge from this continuing process of refinement.

121. Thanks to the computer, courseware provides a living product that can be systematically refined in the light of the statistical information received. There is therefore a need to ensure the portability of courseware follow-up, i.e. the recording and processing of students' responses and their communication to the author.

Section X

THE COMPUTER AS A TOOL FOR EDUCATIONAL RESEARCH

122. As we have seen, courseware is a living product that successive authors can improve in the light of student response to it. In fact the computer as an educational research tool can provide much wider assistance:

a) Contribution of the Computer to Experiments in Cognitive Psychology

123. The computer's value lies in:

i) Its ability to measure and process a large number of variables;

ii) Its ability to store a vast number of experiments;

iii) Its speed;

iv) Its accessibility which, in particular, makes it possible to repeat an experiment with the same subject or with other subjects.

124. At first sight, the conduct of an experiment should not be disrupted by the computer, which is neutral and objective. The role of cognitive psychology is to study the nature of human mental abilities and the processes that bring them to bear on problems under such conditions. Considerable work has been done in the past to determine intellectual capability to perform certain tasks or to make diagnoses with a view to providing a remedy (as in the case of the handicapped or disadvantaged).

125. Other important work has focused on basic learning processes. The following are some examples of where the computer can make a useful contribution:

i) Experiments involving memorising a series of syllables in relation to the time gap between the terms in the series or between different series;

ii) Monitoring the perception of images on a screen in relation to display time;

iii) Discerning frequency patterns in random samples;

iv) Reflexes conditioned by different stimuli.

b) The Opening of New Fields of Research in Cognitive Psychology

126. The development of computers capable of solving statistical or logical problems has had a considerable impact on cognitive psychology. Speech perception has been studied by means of a computer-controlled speech synthesiser. The results throw new light on difficulties of perception and difficulties in speaking a new language. Progress has been made in understanding the processes involved in reading through the use of screens where the display is computer controlled. The Elementary Perceiver and Memoriser (EPAM) Program has been used to gain insight into the perception of a chess player. In another context, the way young children use the LOGO language has thrown new light on "flashes of inspiration" of certain kinds.

c) The Computer's Contribution to the Theory of Cognitive Psychology

127. The computer, by an analogy which needs to be treated with caution, suggests patterns for explaining the operation of the brain and human behaviour:

-- Coding of information;

-- Organisation of information;

-- Operations on this information;

-- Logic constraints on such operations;

-- Time constraints on such operations.

128. Logical, algorithmic and heuristic patterns are not the only ones to consider. The mind also works intuitively and emotionally. The computer can help to clarify these forms of behaviour. The computer's own disruptive role (at second sight) should also be capable of analysis.

129. It is generally accepted that memory is divided into a short-term memory of limited capacity and a long-term memory. Other models depict the strategies used in understanding a text in natural language, the detection threshold theory for hearing a signal against a background of noise, the representatin of knowledge of a vocabulary and the representation of particular images. New knowledge would seem to be understood in relation to old. In presenting a subject, therefore, the educator must, as far as possible, link up with prior knowledge and organise his material in a manner compatible with what can be stored in the memory.

130. The laws deduced from these models, once they have been verified experimentally, can be expressed in quantitative form or by computerised simulation of behaviour. An attempt is being made to find a simulation which corresponds with experience to explain how a child discovers and applies the rules of grammar. There are other examples of rules defined by computer simulation which concern the difference between a novice and an expert.

d) Artificial Intelligence

131. The object of artificial intelligence is to reproduce thought processes that, because of their complexity or their nature, were regarded as possible only for the human intelligence (e.g. analogies, generalisations, hazy logic, etc.). Any problem, for which there is no known algorithmic solution, a priori belongs in the area of artificial intelligence. Initially, this involved solving puzzles, simulating an average chess player or understanding a natural language restricted by a limited vocabulary. It became clear that the system had to acquire knowledge, establish a process of logic and formulate (and at the same time check) the solutions.

132. Existing expert systems employ logic processes and experience stored in a memory and utilised subsequently as appropriate. They are used for:

-- Understanding natural language;

-- Mechanical translation;

-- Problem solving;

-- Demonstrating phenomena;

-- CAI.

133. The STEAMER Program, for example, teaches students how the steam engine operates. The BUGGY Program simulates the results of additions or subtractions done by a student who systematically makes one of the 70 mistakes revealed by actual observation, e.g. a student who confuses number and figure will misunderstand the instruction "add the numbers" (Ex. 1) or "always subtract the smaller number from the larger" (Ex. 2 and 3):

Ex. 1 $\begin{array}{r}17\\+5\\\hline 13\end{array}$ Ex. 2 $\begin{array}{r}41\\-7\\\hline 46\end{array}$ Ex. 3 $\begin{array}{r}328\\-56\\\hline 332\end{array}$

(1 + 7 = 8,
+ 5 = 13) (7 - 1 = 6) (8 - 6 = 2;
5 - 2 = 3)

Normally it is up to the teacher using this program to spot the error of principle which is being made in front of him. The BUGGY Program, on the other hand, is able to spot the systematic error or a combination of several systematic errors made by the student. The diagnosis is followed by corrective exercises and the teacher is informed of the student's performance and progress. In the words of J.L. Laurière, "The degree of detail of artificial intelligence programs highlights the shortcomings, in every discipline, of conventional types of instruction and brings out things about which, usually nothing is said in education."

e) Educational Research Prompted by the Writing of Courseware

134. It soon becomes apparent to the author, or rather to the team that puts together a courseware package, that they need to go through a process of

thinking that is somewhat in the nature of epistemological and pluridisciplinary research, or a process of rediscovery:

i) Rediscovery of the subject matter to be taught. This has to be approached in a rigorous, accurate and unequivocal manner when preparing courseware. Concepts must be precisely defined, a recognised vocabulary used and there must be no doubt as to the objective to be achieved and tested;

ii) Rediscovery of the way to teach. The vast variety of possible teaching strategies, routes that can be followed and ways of asking questions make it essential to re-assess the advantages and disadvantages of particular procedures;

iii) Rediscovery of the difficulties of learning. Courseware follow-up will reveal the mistakes made by the students and it is then necessary to discover why the mistakes were made and find the right remedies;

iv) Rediscovery of the difficulties of assessing either the student or one's own teaching. This personal educational appraisal by the teacher himself rarely occurs outside the context of CAI. The computer is an instrument of measurement and teachers and students alike must learn how to derive the utmost benefit from it.

Section XI

TRAINING IN THE USE AND PRODUCTION OF COURSEWARE

135. Training in the use and production of courseware depends on how the teacher and student use the product. The teacher may use the one-screen multimedia system as a modern electronic version of the traditional blackboard. The simplest uses already current are:

i) Drawing curves, displaying how they alter in experimental conditions (mathematics, physics, chemistry, biology, sociology, economics, etc.);

ii) Animations, to represent a movement, a view in space, a statistical trend, a sum of series or functions;

iii) Calling up a data bank with class participation;

iv) Courseware adapted to the responses of a whole class.

136. If the teacher has one terminal available for one, two or three students, he can let them work at their own pace without intervening. But he can also intervene by visiting students in succession. If he has a master terminal or mainframe, he can intervene directly in the running of the package from his desk, where he can monitor all the students' progress. In some cases, the teacher divides his class into two parts, working more or less traditionally with one-half while the others come to grips with the terminals. Experience shows that the latter become involved in lively discussions among themselves and with the teacher, whose role often then calls for discretion.

137. The teacher's task is different again if terminals are not in the classroom but at home or in a freely accessible library. If the teacher has a master terminal or mainframe linked (sometimes remotely) to the students' terminal, he is in the same situation as above except that he cannot see the students themselves but only what is displayed on their screens. Telephone (or even visiophone) communication would be conceivable but otherwise, the teacher has to work after the event, analysing how the recorded interactions have proceeded. The system itself can help him to do this, by providing overall results and statistics for the individual student, class or package.

138. On the whole teachers like to be able to easily introduce a few changes, personal or associated with the particular time and place. They

would prefer their role not to be limited to one of mere mediator between student and system. Teachers must be given creative possibilities, without overlooking the risks that an overenthusiastic teacher or small team might go off on a tangent. The training provided should, conversely, neutralise the difficulties inherent in any institutional change in a school.

139. Training in data processing, documentation and telecommunications is of course useful, but here we will concentrate on training in the educational applications of computers and audio-visual communications media, taking as the main headings in this respect their use as a teaching aid, as a technique or as a science depending on the level of training required.

140. The press, radio, television, conferences and exhibitions are creating an awareness among the public of the educational possibilities of electronic games and, by extension, of the multi-media combinations controlled by microprocessor. There is a substantial demand for training in these new educational techniques from teachers and instructors in the teaching profession, in firms of various size and in clubs.

141. The training OBJECTIVES can be graded in several levels, ranging from straightforward initiation to training of researchers in education sciences by means of interactive audio-visual media to enable them to acquire skills in computer techniques, communications, audio-visual aids, teaching methods, etc.

142. The training METHODS can be of various kinds:

- Self-instruction of a teacher or a group;
- Guided instruction, i.e. programmed teaching with the aid of a computer;
- Short-cycle training, i.e. about 100 hours of supervised instruction;
- Long-cycle training, i.e. about 1 000 hours of supervised instruction.

a) Initiation

143. Initiation is possible by reading one of the dozens of periodicals, the handbooks for microcomputer users or from lectures on television. In some cases, a software package is supplied with the microcomputer so that the novice can see its various capabilities as regards operation, computation, display, etc. and manipulate sample dialogues, games or educational simulations. Workshops, training courses and clubs also assist in this process of initiation by providing demonstrations on inexpensive hardware. There are associations which those interested can join (e.g. ADCIS in the United States which is international in character, RECODIC for French-speaking chemists, etc.).

b) Using Courseware

144. The question is one of knowing how to use courseware as a demonstration tool for the teacher or as a medium for a student/machine dialogue. The main

difficulty is choosing a hardware package from amongst those which are compatible with the system used. Some organisations (CNDP in France, CEDAR in the UK, CONDUIT in the United States, etc.) try to help the teacher by providing an appropriate bibliography or even videotaped extracts of courseware material. A courseware package will, in many cases, be accompanied by a descriptive document describing the teaching aims, level and strategy. Once the choice of courseware has been made, it is then a question of being able to use it properly and understanding, in broad outline, the way in which the system operates -- which is what the student's or teacher's handbook should explain.

145. Some multimedia programs guide the user, as does the "Microprimer" program, designed for primary school teachers in the UK using the BBC microcomputer. The program guides them through the taped audio material, the explanatory literature and the microcomputer software. The user thus learns the rudiments as regards the hardware, programming and possible uses. In a short-cycle training course, the emphasis will be essentially on general knowledge of computers and their applications in modern-day society (including databanks and videotex) and, in particular, on the acquisition of the ability needed to use courseware in education with various types of terminal from slide projector to videodisc.

c) Modifying Simple Courseware

146. Modification may involve anything from simply up-dating the courseware (places, dates, etc.) to constructing a new courseware package based on a well-proven teaching strategy, in which case, it is necessary to know how to interpret and adapt, with the aid of the user's guide, all the instructions written in a computer or authoring language. Often, this knowledge can be self-acquired. Prompt modes are possible in the case of rigidly defined teaching strategies. A short-cycle training course is recommended and is sufficient to reach this level.

d) Production of Simple Courseware

147. Using low-level authoring languages, it is possible to construct teaching dialogues with conditional branching and limited response analysis. The authors can thus concentrate on the teaching problems and receive the appropriate training. In the case of self-instruction, group discussions are, in practice, necessary. Authoring languages will, in most cases, have prompt modes. Various guides, like those distributed by CONDUIT, give advice on the drafting of teaching material including supporting documents. A short-cycle training course should include these teaching techniques and provide some additional knowledge of computers: utilities, procedures, functions, connection of terminals and computers.

e) Production of Standard High-quality Courseware

148. Here we refer to courseware for which the facilities of an audio-visual studio are not necessary. By using the functions of a fairly complete authoring language the courseware can be written without constraints as regards teaching strategies and without problems of programming. In the case

of standard teaching strategies, a prompt mode can be used and avoids the problem of selecting implicit instructions (e.g. allow for blank spaces or not, upper case/lower case, limitations in the loops, etc.).

149. In a short training course, it is not possible to develop the instruction on computers, since the teaching aspect has to take precedence, i.e. definition of the subject matter, how the microcomputer can help, definition of objectives, analysis of tasks, observation of user reactions, pre-test and post-test, choice of teaching strategy, choice of terminal, writing of supporting documents, tests, comprehension of texts, readability of program, student and teacher reaction, etc.

150. A long-cycle training course would be better, covering a full year, and divided into three roughly equal parts:

i) Data processing aspects: structure of computers, peripherals and data transmission, operating systems, knowledge of a number of languages including BASIC and Pascal, structure of data and methods of program design and authoring systems. Standard and specialised applications of computers should also be dealt with, i.e. databanks, text editors, CAD (computer-aided design), CAM (computer-aided manufacturing), CAT (computer-aided translation), etc;

ii) Teaching applications covering the contribution of computers to education, their different applications and the stages of designing, testing and validating courseware material. The education aspect of the training should cover teaching methods and educational psychology, i.e. learning, the cognitive processes, the objectives of education, the characteristics of students, the diagnosis of their errors or inability to understand, the presentation which is most suited to them or which they themselves might prefer. This part of the training should be rounded off by individual or preferably group work with an experienced team;

iii) Career training: work experience in different schools and in documentation and distribution centres in order to provide an insight into the difficulties encountered by teachers using computers in their work. The running of CAI centres or computer clubs in schools will be facilitated by the contacts built up during the course of this work experience. In addition, training needs to be provided on the operation of the hardware and light maintenance.

f) Creation of Original Courseware

151. Some parts cannot be dealt with using an authoring language. This is often the case with simulation, learning games or artificial intelligence where a special module has to be written in a computer language. The author or authors must be thoroughly familiar with all of the above aspects and be able to manipulate the graphic and animation capabilities of the computer. At this stage, it becomes useful to know something about the concepts of artificial intelligence. The level of training has to be equivalent to that

of research. It is available in universities and institutes at undergraduate level culminating in a degree in computer science, telecommunications or education.

g) Production of Complex Courseware

152. By this is meant courseware such as that used for training pilots for which substantial audio-visual facilities are required, i.e. television studios, videodisc, etc (see Ancient History Scenario, Section I, para. 11).

153. The facilities required are something like those needed for making a film or television programme. Training in these audio-visual techniques needs to include studying the different situations where the computer linkup offers new scope, e.g. audio-visual databanks, videodisc operation, computer-aided design, computer animation, etc.

Annexe 1

ACRONYMS

		Equivalents in French
CAI	Computer Assisted (Aided) Instruction	EAO Enseignement Assisté par Ordinateurs
CAL	" " " Learning	
CAT	" " " Teaching	
CBE	Computer Based Education	
CBL	" " Learning	
CBT	" " Training	
CMI	" " Instruction	
MCQ	Multiple Choice Question	QCM : Question à Choix Multiple
MCR	Multiple Choice Response	

Annex 2

BASIC GLOSSARY

I. COMPUTER TERMINOLOGY

COMPATIBILITY (Compatibilité):
Feature of any hardware or software that a computer system can work with.

COMPUTER GRAPHICS (Graphique):
Using a computer to generate and display graphics. Several curves can be displayed simultaneously and a variety of colours (or shades of grey) can be used.

COMPUTER LANGUAGE (Langage):
Language in which a programmer or user instructs the computer.

DISKETTE, FLOPPY DISK (Disquette):
A flexible magnetic disk of smaller size and capacity.

EDITOR (Editeur):
Software tool helping to produce other software. For example:

- -- Databank;
- -- Character set;
- -- Screen;
- -- Graphics;
- -- Text editors.

HARDWARE (Matériel):
Set of physical components used to process information.

MAGNETIC DISK (Disque magnétique):
A magnetically coated disk on which data are recorded.

MENU (Menu)
List of options or facilities to be chosen for instructing a computer. A menu is usually displayed on the VDU with a selector symbol for the user to position on the screen. A CAI can have a large number of menus.

PERIPHERAL (Périphérique):
A device connected to the central computer for data entry, storage or output: e.g. a printer, VDU, mass storage.

SOFTWARE (Logiciel):
Set of programs, processes and rules, possibly with documentation, relating to the operation of an information processing system.

TERMINAL (Terminal):
Device for remote access to a computer system.

TRANSPORTABILITY (Portabilité):
The ability of a program to run on different types of computer system.

VIDEODISC (Vidéodisque):
A process for the storage of animated sequences and fixed images and for their reproduction on a home television screen.

VIEWDATA, VIDEOTEX, (Vidéotex):
A system enabling a home television screen to call up pages of alphanumeric and graphic information via the telephone network. The user can send messages back and thus interact with the computer.

VISUAL DISPLAY UNIT, DISPLAY DEVICE/TUBE, VDU (Visu):
Equipment for the visual, temporary display of information.

II. CAI TERMINOLOGY

AUTHORING LANGUAGE (Langage auteur):
A computer language more or less closely related to a natural language with which an author can instruct the CAI system.

CAI (CBL, CBT SYSTEM) (Système EAO):
Combination of hardware and software resources with which to create, modify, execute and disseminate courseware. Software resources are usually distinguished between those intended for authors, those for teachers and those for learners. The following parts are often distinguished:

-- Administrative (administration);
-- Authoring (auteur);
-- Presentation (présentation).

COMPUTER ASSISTED INSTRUCTION (CAI, CBL, CBT)
(Enseignement assisté par ordinateur, EAO):
Interactive use of the computer as an educational tool at the centre of an educational relationship between learners and teachers. Broadly, this involves two dovetailing parts: the education part (CAI, CAL), the presentation of interactions, analysis of responses, comments, etc.; and the management part (CMI) initiating the student, branching, educational follow-up. Some English-speaking writers refer to all of these as computer based learning (CBL) or computer based training (CBT).

COURSEWARE (Didacticiel):
A complete educational package for use on a CAI system to achieve an overall educational goal.

COURSEWARE EDITOR (Editeur de didacticiel):
Software tool enabling the courseware author to concentrate on the educational goal and concern himself as little as possible with the computer side. Examples (in addition to the ordinary editors) are those for:

-- Dialogue;
-- Educational situations;
-- Scenes;
-- Prompt/queues;
-- Response analysis;
-- Response assessment;
-- Decision unit;
-- Environment;
-- Courseware.

RESPONSE ANALYSIS (Analyse de réponse):
Testing for a match between a learner's answer and the answers expected by the author. Each form of response expected, such as a numerical or textual response or an answer to a multiple-choice question, has its own analytical process.

Annex 3

ADDITIONAL GLOSSARY

I. COMPUTER TERMS

ALGORITHM (Algorithme):
A set of instructions precisely indicating the order in which a combination of operations must be performed to obtain solutions to all problems of a given type. The number of operations described and the number of operations implemented must be finite.

CHARACTER SET (Police de caractère):
Set of character shapes and sizes available for display on screen, or output on printer.

CONVERSATIONAL MODE (Mode dialogue):
Data processing mode in which the users can interact with the system.

DIGITAL, NUMERICAL, NUMERIC (Numérique):
Representation of data, physical magnitudes by means of characters, usually figures, rather than by electronic analogy and hence, any system, device or process for data when represented digitally.

EXPERT SYSTEM (Système-expert):
A system simulating the reasoning procedures of a human expert. The computer is given general rules (strict or approximate) enabling the program running them to draw conclusions, perhaps in terms of probabilities, from data introduced.

INFOGRAPHY (Infographie):
Application of computers to graphic presentation and picture processing.

INFORMATION TECHNOLOGY, "TELEMATICS" (Télématique):
Refers to all techniques and services involving both computers and telecommunications.

INTERACTIVE (Interactif):
Describes hardware, software or operating conditions in which the user can interact with the system in real-time conversational mode.

JOYSTICK (Manche à balai):
Moveable device for pointing on the screen.

LIGHT PEN (Photostyle):
Input device which the operator can point directly at a VDU screen.

MICROPROCESSOR (Microprocesseur):
Miniaturised processor all of whose components are in principle combined in a single integrated circuit.

MIPS (MIPS):
Million instructions per second (for data transmission speed).

MOUSE (Souris):
Device whose movement over a surface controls a VDU cursor (as a joystick does).

OPERATING SYSTEM, OS (Système d'exploitation):
The software which manages a computer. It is independent of the application programs but essential for running them.

PIXEL (Pixel):
Smallest picture element on a VDU screen. The whole screen area consists of rows and columns of pixels. The number of pixels determines graphic detail quality.

PROCESSOR (Processeur):
Part of a computer or other machine which interprets and executes instructions. By analogy, set of programs allowing the computer to implement programs written in a particular language.

PROM CARTRIDGES (Cartouches prom):
Software in the form of a plug-in module. Programmable read-only memory (PROM) (mémoire morte programmable).

RANDOM ACCESS MEMORY, RAM (A accès aléatoire, mémoire vive):
Memory which need not be accessed sequentially and whose content can be altered in ordinary use.

READ ONLY MEMORY, ROM (Mémoire morte)
Memory whose content cannot be altered in normal use.

STORAGE, MEMORY (Mémoire):
Device for recording, storing and recovering data.

SOFTWARE PACKAGE (Progiciel):
Complete, documented set of programs designed to be supplied to more than one user for a given application.

TOUCH SENSITIVE (Tactile):
Refers to a screen which can recognise that part of its area has been touched for input purposes.

UTILITIES (Utilitaires):
Programs available to the operating system so that the programmer need not keep writing outlines of instructions for frequently recurring tasks.

II. CAI TERMS

BRANCHING (Branchement):
Number of routes through which the student may be guided after replying to a question or prompt. The branch can in principle be selected according to the student's most recent answer, together with earlier answers, the teacher's decision or the choice of the student himself.

CAPABILITY (Fonctionnalité):
Analysed from a capability point of view by teachers, a CAI system includes basic educational capabilities essential for the development and use of the courseware. These are "capabilities" common to any CAI system defined independently of any implementation.

CANONICAL FORM (Forme canonique):
For every form of answer expected there may correspond a "canonical form" in which the answers expected by the author are expressed and into which the learner's answers are also transformed before analysis.

DECISION UNIT (Unité de décision):
A decision unit designates, after a calculation involving the dialogue environment in particular, the sequence of actions to be performed (e.g. the next interaction unit).

ENVIRONMENT (Environnement):
Set of information accessible at any moment for interaction and educational follow-up. The system either updates it automatically or on request by the author while using the system. The information allows for follow-up of lessonware, courseware and students.

A distinction is made between:

-- Lessonware environment;
-- Courseware environment;
-- Pupil environment.

FOLLOW-UP (Suivi):
Set of information describing the results of using a courseware package. The information is classified according to dialogue, courseware and pupil environments.

IMPLICITS (Implicites):
Instructions implicitly assumed throughout a courseware package but contained in the set of programs guiding the computer. Implicits may be systematic for a given system, or may be defined by the author. For example:

-- Ignore blanks, incorrect use of upper case/lower case, spelling errors;

-- Restrict the coupling factor to the value of three, lower the level of questions asked after two successive mistakes;

-- Accept authorised requests.

INTERACTION UNIT (Unité d'interaction):
Combination of actions corresponding to a learner/system interaction, on the initiative of the author:

-- Output author information;

-- Output question or prompt

-- Take in learner messages;

-- Discriminate between answer and request;

-- Reduce to canonical form;

-- Analyse answer;

-- Output comment reflecting the result of the analysis.

LESSONWARE (Dialogue):
Smallest coherent pedagogical unit that can be presented to the learner with a view to achieving one specific teaching goal. Interaction is an indivisible subject of a courseware package. Lessonware is an indivisible subset of courseware. It is self-standing and can be used in different contexts and different courseware packages by a teacher who need not necessarily have written it himself. Lessonware can include components which the teacher using it can modify.

LINK UNIT (Unité de liaison):
A link unit is associated with the dialogue and describes the condition for moving on to other dialogues according to the courseware and pupil environments.

LOOPING FACTOR (Facteur de bouclage):
When the student does not give the expected answer, the maximum number of times the question is asked in the same form.

PEDAGOGICAL OBJECT (Objet pédagogique)
The word "object" can designate an item of information as well as an action. A pedagogical object is of direct interest to the teacher. Examples of objects are: a message intended for the learner, the action of sending such a message.

PEDAGOGICAL SITUATION (Situation pédagogique)
Combination of activities permitting an exchange with the learner and the move on to the next pedagogical situation. For example, the combination of one unit of interaction and one associated decision unit.

PROMPT/CUE (Sollicitation):

Expectation of some action on the part of the learner. For example, after asking a question, a reply is prompted: the system stands by until the learner uses the resources at his disposal to formulate his reply; the learner can also make a request.

REQUEST (Requête)

Introduced on the initiative of the learner, a request calls up resources outside the current interaction, e.g. for consulting a dictionary, performing a calculation.

SCENE (Scène)

Organised set of elementary informative messages intended for the learner. A scene deploys different sources of information: visual, sound, audio-visual, etc.

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ECONOMIC ASPECTS OF THE INTRODUCTION OF NEW INFORMATION TECHNOLOGIES IN EDUCATION

(Note by the Secretariat)

1. The attached report, has been prepared by Jean Claude Eicher, Director of the Institut de recherche sur l'économie de l'éducation (IREDU), France, in his capacity as consultant to the Secretariat. It will serve as a background report for the Plenary Session on Theme 2 and in Working Groups 1 and 5.

2. The views expressed in this document are those of the author and do not commit either the Organisation or the national authorities concerned.

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INTRODUCTION

1. It is now fifteen years since Philip Coombs predicted, in what has remained a best-seller, the "world crisis in education". During the 1970s, following the "period of elation" described by Thorsten Husen, doubts began to spread about the benefits of expanding educational systems. Worries caused by the excessively fast rise in the financial burden on public budgets were compounded by the doubts raised by the development of graduate unemployment.

2. In the developing countries, increasingly sharp criticism was heard about the unsuitability of curricula and syllabus contents for local requirements and lifestyles. In industrialised countries, from the onset of the world economic crisis, those hardest hit by unemployment were in practically every case school leavers without any academic qualifications or real vocational training. Whilst this observation in a way tended to reinforce belief in the economic benefits of qualifications, it also called into question the capacity of traditional education systems to provide all young persons with training to match their capabilities and meet society's needs.

3. Moreover, new requirements were emerging or expanding. There was a sharp rise in the number of adults wishing to supplement or complete their training or start afresh, either to improve their employment or career prospects or to make better use of their leisure time. "Marginal" groups (the handicapped, the sick, immigrants and their families, etc.) found better recognition of their specific needs. In short, doubts were being voiced about the ability of traditional educational systems, which had retained more or less the same organisation for many decades, to effectively meet all the demands made of them.

4. In view of the growing costs per pupil and the lack of correspondance between the services supplied and actual requirements, economists are tempted to argue in terms of productivity and seek optimum production techniques. However, education is not an ordinary market product. Indeed, it is difficult to define: e.g., transmission of knowledge or of know-how, broadening the mind, inculcation of attitudes, brain-training? It is all that and probably more. Even the link between inputs and this ill-defined output is not clear. The ability of teachers to teach does not seem to be connected in any specific way to their level of qualification. The complementarity between teaching aids and teachers means that the former's contribution cannot be easily identified. But there is also the fact that whereas production techniques for almost all goods have been altered radically by technical progress, educational services continue to be supplied by a production system based on skilled labour.

5. It was therefore tempting to try to replace teachers by machines in order to improve productivity in this sector of production. Unfortunately, the introduction of "modern educational facilities" has not always had the positive outcome that might have been hoped for. On the whole, the balance tends to be negative throughout the traditional education system. Should the possibility of modifying the "production function" of education therefore be abandoned? The spread of new information technologies (NIT) is currently raising high hopes, and many believe that discerning and widescale use of such technologies might this time enable most requirements to be met under highly satisfactory economic viability conditions. What is the truth of the matter?

6. This is the question this report will try to answer, first by reviewing the facts on educational costs and their recent trends, then showing the reasons why it is now essential to improve the economic effectiveness of educational systems, why "modern educational facilities" have not succeeded in doing so and why there is hope that, on the contrary, the introduction of NIT will. Two exploratory chapters will then review available information on NIT costs and efficiency (both internal and external), identify the remaining gaps that need to be filled to confirm the diagnosis and try to draw conclusions on the future of educational systems.

Chapter I

THE NECESSARY REFORM OF EDUCATION SYSTEMS

7. There are glaring inadequacies in the information available on education costs. An essential prerequisite for the comparative economic evaluation of different education systems is the rationalisation of concepts and more reliable statistics. Some discussion of the main problems and possible remedies are presented in annex (see Annex 1). Despite their limitations, however, the available data do reflect both the extent of public efforts in favour of education and the fact that a ceiling now seems to have been reached. Other observations seem to indicate a marked drop in the efficiency of traditional education systems and the virtual failure of modern efforts based on the media.

8. It is therefore necessary to look for other solutions. A number of factors seem to suggest that the large-scale use of new information technologies has a high potential efficiency.

A. TRENDS IN EDUCATION EXPENDITURE AND THE CONSEQUENCES THEREOF

9. Despite the inadequacies and gaps in the data, information on public expenditure on education is available for many countries and over a fairly long period. It is not so easy to study in detail changes in the breakdown of this expenditure, but a number of interesting pointers can be identified. Lastly, public efforts in favour of education and changes in them warrant study.

1. General Trends in Public Expenditure on Education

10. The time series available do not generally cover the whole of public expenditure, but only that by the central government (or regional authorities in decentralised countries) and not that by local authorities, or are even limited to expenditure by the Ministry of Education. Even for the developed countries, differences in coverage and definition mean that individual comparisons must be treated with caution. Despite a recent concertation and harmonisation effort between UNESCO and OECD, the series from the two sources still differ. Despite these limitations, the general trends can still be identified:

a) General Trends since 1960

11. These trends are meaningless unless expressed in constant currency terms. In spite of the conversion difficulties encountered, the main tendencies can be identified.

Table 1

TREND IN PUBLIC EXPENDITURE ON EDUCATION BETWEEN
1960 AND 1976 BY MAJOR REGION

REGIONS	Annual Average Growth Rate			
	1960-65	1965-70	1970-74	1974-76
Europe (excluding socialist countries)	+10.1	+4.3	+8.18	+4.57
Socialist countries in Europe			+6.55	+6.66
North America	+12.0	+7.9	+3.5	-1.3
Africa	+10.6	+9.1	+8.8	-10.1
Asia (excluding Japan)	+9.1	+7.6	+7.6	+25.7 (1)
Latin America	+13.1	+6.2	+9.4	+2.2
Developing countries	+10.8	+7.3	+8.5	+14.2 (2)
Developed countries	10.9	+6.4	+6.5	+2.3

(1) +11.2 excluding OPEC Member countries.
(2) +4,6 excluding OPEC Member countries.

Source: J.C. Eicher and F. Orivel: The allocation of educational resources in the world. UNESCO, Statistical Office, November 1979

The two most striking features are first the very rapid rate of increase in pulic expenditure on education at the beginning of the period and, second, the slower rate since 1970 and especially since the onset of the economic crisis (except in the oil producing countries).

b) Trends since 1970 in OECD countries (see Table 2)

12. On the whole, the recent growth rate is lower than it was. The effects of the crisis are clearly visible since expenditure decreased between 1974 and 1976 in four countries and rose only slightly in most others. However this

Table 2

RECENT TRENDS (1970-1979) IN EDUCATION EXPENDITURE IN OECD COUNTRIES
(in millions of 1976 $)

PAYS	Montant de la dépense				Tx croissance /an 1974-1979
	1970	1974	1976	1979	
Canada	11 696	12 301	14 176	11 882	-0.7
U.S.A.	92 730	106 916	102 033	119 325	+2.2
Japan	16 064	27 231	30 589	45 930	+11.1
Austria	1 459	2 113	2 391	3 001	+7.0
Belgium	2 242	4 007	3 941	6 286	+9.4
Denmark	2 011	2 939	3 044	3 036	+0.6
France	12 700	17 401	20 610	23 618	+6.3
Germany	13 816	20 998	23 146	26 902	+5.1
Greece	368	394	-	572	+7.7
Ireland	359	462	512	770	+7.5
Italy	6 794	9 809	9 267	9 438	-0.8
Luxemburg	90	121	-	205	+11.1
Netherlands	5 393	6 996	7 269	11 749	+9.2
Norway	1 337	1 953	2 425	2 578	+5.7
Portugal	160	334	585	21	-2.6
Sweden	4 665	5 148	5 715	7 221	+7.0
Switzerland	2 216	2 913	3 052	3 889	+5.9
United Kingdom	10 284	14 656	-	15 242	+0.8
Australia	2 905	5 310	5 427	6 276	+3.4
New Zealand	661	875	722	810	-1.5

Source: Author's calculations on the basis of UNESCO Statistical Yearbooks reduction was merely temporary in most cases and expenditure began to rise again, although more slowly than before. There is a certain relationship between this trend and that of school demography which is characterised in most countries by reduced numbers of pupils in primary education and stabilisation in secondary. It would be mistaken, however, to conclude that continued low birth rates since 1975 should permit substantial reductions in educational expenditure during the 80s. The fact is that close study of the statistics and of policy measures shows that in most cases reduced pupil numbers have led to improved staff/pupil ratios, not to the standing down of a certain number of teachers, for their terms of employment usually protect them against redundancy.

2. Structure of Expenditure

13. It would be useful to have information on trends in the two main items likely to be directly influenced by the introduction of NIT, teachers' salaries and "teaching aids". Unfortunately the data available are incomplete and lacking in homogeneity. The data that seem to be the most reliable have been grouped below (see Table 3).

14. It can be seen immediately that teachers' salaries invariably form the largest item in the education budget (on average slightly more than two-thirds of current expenditure) in the countries observed. The table also shows that recently, the relative share of this item has increased in most countries (9 out of 14), the opposite trend being clear in only three countries, two of them Scandanavian (1). This confirms the previous observation, as salaries constitute the most difficult item to squeeze at a time of budget constraints, teachers usually being protected by powerful trade unions and by their public servant status.

3. Trends in the Public Educational Effort

a) Parameter selection problems

15. In order to understand the causes of the observed trends, it is important to know whether the latter are due to external constraints (or to changes in them) or whether they arise from a voluntary change in attitude towards education. Two parameters (others are possible) can be used to arrive at a diagnosis:

i) Cost per pupil, reflecting the quality of educational services; and

ii) The share of national resources used to finance education, reflecting the public educational effort.

b) Trend in Expenditure per Pupil

16. Since general trends embracing all levels of study would not make any sense, the following tables show series in constant currency for selected countries at primary and post-secondary levels. It may be noted that expenditure per pupil is invariably rising, often at a high rate. The same calculation for secondary education would not be very meaningful because of the differences between school systems and statistical definitions. However, spot checks show that the trends are fairly similar to those in primary education.

Table 3

TREND IN THE SHARE OF TEACHERS' SALARIES IN CURRENT PUBLIC EXPENDITURE ON EDUCATION IN WESTERN EUROPE (1975-1979)

PAYS	Teachers' salaries as a % total current expenditure		
	1975	1979	1980
Germany	71.9	72.4	-
Austria	48.1	49.5	53.1
Belgium	72.3	74.2	[illegible]
France	72.5	74.4	78.6
Greece	74.2	82.2	-
Ireland	70.4	66.0	67.6
Italy	73.4	68.2	-
Luxemburg	80.8	88.3	87.8
Norway	71.3	64.4 (1978)	49.1
Netherlands	75.5	74.1	73.5
Portugal	78.8	82.5	82.8
Sweden	52.4	44.4	46.5
Switzerland	61.5	61.7	61.0
United Kingdom	51.1 (1972)	50.2	-

Source: UNESCO Statistical Yearbook, 1983, table 4.2 and 1976 Yearbook, table 6.2.

Table 4

TREND IN PUBLIC EXPENDITURE ON PRIMARY EDUCATION PER PUPIL IN SELECTED OECD COUNTRIES (1965-1979)

COUNTRY	Total expenditure (1)		
	1965	1970	1979
Japan	58 096	84 082	132 408
France	808.8	1 181	1 316.2
Germany	943	1 276	2 584.6
Italy	201 458	156 700	191 333
Netherlands	928	940	1 613
Sweden	3 293	5 001	7 949
United Kingdom	89.5	83	143.9 (78)

(1) In 1970 monetary units.

Source: Author's calculations on the basis of the data in UNESCO yearbooks.

17. The same situation does not arise, however, in higher education, as shown in Table 5. At this level, there is a downward trend in expenditure in constant currency. In a few countries it started even before 1970, but became more or less generalised during the 1970s. This is chiefly due to the fact that staff/pupil ratios have deteriorated and, in most cases, general running expenditure (excluding salaries) has diminished in relative terms. There are therefore grounds to believe that the reduced expenditure is due mainly to a fall in the quality of education rather than to a rise in productivity with quality remaining constant.

c) Expenditure as a Percentage of GNP

18. Trends since 1960 by broad area, as in Table 6, show a sharp rise in expenditure during the 1960s but this was followed by a slowing down or reduction even in many developed countries since the early, and especially the mid-1970s. In Western Europe and North America expenditure on education has now levelled out and the most recent figures seem to confirm this new tendency. Examination of recent trends in a number of OECD countries, as shown in Annex 2, confirms this view.

Table 5

TRENDS IN PUBLIC EXPENDITURE ON POST-SECONDARY EDUCATION PER PUPIL ON A FEW OECD COUNTRIES (1965-1979)

COUNTRY	Total Expenditure (1)		
	1965	1970	1979
Canada	2 756	2 585	2 887
U.S.A.	2 046	2 302	-
Japan	516 300	630 811	546 192
France	6 091	7 704	4 517
Germany	5 953	6 354	4 579
Italy	362 369	400 048	280 895
Netherlands	12 293	12 886	9 113
Sweden	10 087	11 292	17 039
United Kingdom	871	844	741

(1) At 1970 prices.

Source: See Table 4.

B. IMPROVING EDUCATION EFFICIENCY -- PROBLEMS AND NEEDS

19. The figures show that the efficiency of traditional educational systems has considerably decreased. The efforts made to "modernise" education by introducing "modern educational facilities" have had very mixed and, on the whole, not very positive results. However, new information technologies seem to present a potentially efficient solution to at least some of the educational problems.

1. Growing Inefficiency of the Traditional System

20. Educational systems even today are characterised by the use of "production techniques" based on skilled labour, which have hardly changed for

Table 6

TRENDS IN PUBLIC EXPENDITURE ON EDUCATION AS A PERCENTAGE OF GNP SPENT ON EDUCATION (1960-1979)

REGIONS	Years					
	1960	1965	1970	1974	1976	1979
Developing countries	2.35	3.07	3.52	3.43	3.99	-
Developed countries	3.95	5.14	5.54	5.95	6.00	-
Western Europe	-	-	4.56	5.21	5.61	5.64
North America	3.9	5.4	6.5	6.4	6.2	6.5

Source: Eicher and Orivel, op. cit., updated by J. C. Eicher.

centuries. However their efficiency is increasingly called into question owing to:

i) The rise in the unit costs of education;

ii) The inability of education systems to meet all the objectives now set for them.

a) Rising Costs

21. Costs are high everywhere (see Section A). Several considerations suggest that this tendency is unlikely to be reversed:

i) The increase in requirements (extension of basic training and proliferation of adult training schemes) is leading to an equally rapid growth in total expenditure for a constant quality since, but for a few exceptions, there are no economies of scale because of the production techniques used;

ii) The concern to improve the quality of educational services and in particular the qualification level of teachers is increasing the cost per pupil;

iii) Less-developed countries are encouraged to bring the standards of their schools closer to those in more affluent countries;

iv) The protected status of teachers prohibits any major reduction in staff costs, whether in the form of salary cuts or an increase in educational duties.

22. There is no similar increase in the quality of education. The main reasons for this are as follows:

i) Following the intensive recruitment that prevailed everywhere between the mid-50s and the end of the 60s, the average age of teachers is rising and teaching staff costs are increasing automatically owing to promotions based on length of service, even in the absence of new recruitment;

ii) The pressure on the budget caused by automatic salary increases means in most cases that expenditure on teaching aids, on which education quality partly depends, has to be contained or even reduced;

iii) The considerable expansion in all educational systems has resulted in a more cumbersome administrative organisation and hence heavier administration costs, without leading to improved education.

b) Falling Efficiency

23. In some cases, this was the logical consequence of the lower quality of the educational services provided (see above). However, even where it has been possible to maintain or even improve quality, traditional systems have become less efficient because the situation has changed.

-- The traditional school is not suited to the transition from the training of the élite to mass education. The main reasons are uneven standards within classes, new pupil groups unable to adapt to classroom teaching, counter-productive allocation of teachers (inexperienced or less well-trained teachers being sent to rural areas and/or vocational streams, etc.);

-- The traditional school is increasingly competing with other sources of information and other training methods:

i) The media, especially television, transmit information and knowledge in a more attractive form competing with that supplied by the teacher, and are felt to be more interesting and more up-to-date;

ii) The specialised technological training supplied by technical education establishments is becoming more and more unsuited to the requirements of businesses using rapidly advancing technology.

23. At the request of the business world, large numbers of more independent, and therefore more flexible, specialised bodies have been created as they can tailor educational content to requirements more easily and apply new teaching techniques using more efficient aids.

-- New forms of demand have appeared.

24. The traditional school system was addressed to children and some adolescents. Nowadays, further categories of adolescents and, above all, different groups of adults are also demanding training:

-- Adolescents wishing to continue their studies nowadays often request vocation-oriented instruction within a less constricting framework than the traditional school;

-- More and more adults in active life are seeking to update their technical knowledge and/or to supplement their initial training without having to "go back to school";

-- More and more adults from a widening range of categories (housewives, pensioners, workers) are seeking to acquire information and training under flexible systems;

-- There is growing awareness that specific categories (the handicapped, the sick, children of immigrant workers, etc) are unable to fully benefit from education as supplied in traditional schools.

25. It is therefore necessary to find new solutions in order to meet new requirements satisfactorily, while remaining within an acceptable financial budget and improving the efficiency of education.

2. Relative Failure of the "Old" New Technologies

26. The problem of modernising education is by no means new. It was already realised over ten years ago that it would not be possible to provide universal basic schooling that would meet the requirements of the poorest countries without radical changes in the system. Attempts have already been made for over 20 years to renovate education in affluent countries by introducing modern equipment (radio, television, other audio-visual and/or audio-oral aids) at school and to experiment with the possibility of computer-assisted instruction. However, these experiments did not become general practice for the following reasons:

a) On the whole, the impact on costs was not positive

27. In traditional education:
In most cases, new equipment was supplied in addition to the traditional teaching aids, so costs went up. The experiments replacing teachers by machines (i.e. by replacing qualified teachers by assistants or by reducing the number of teacher-pupil contact hours so as to reduce the number of teachers) failed:

i) Effective use of such methods in fact requires highly qualified staff (e.g. TV primary education in the Ivory Coast);

ii) Administrative constraints and the bargaining strength of teacher's trade unions compared with the public authorities have generally prevented any direct or indirect replacement of men by machines.

Because the use of recorded programmes has not spread sufficiently the unit cost is still high.

28. Distance learning: One of the obvious advantages of the media is that

they make home study courses possible, in other words pupils do not have to assemble together at the same spot to listen to a lesson delivered by a teacher in front of them. This type of education is characterised by high fixed costs and low variable costs (compared with traditional education). Most design, production and transmission costs are fixed, i.e. independent of the number of pupils. On the other hand, the reception costs are to a large extent variable.

29. This has two implications:

i) The cost per pupil (or per contact-hour) diminishes with increasing numbers of pupils. The threshold beyond which this formula becomes competitive varies depending on the medium (or combination of media) used. Surveys show that radio broadcasting is the only method presenting guaranteed profitability (2);

ii) The cost may be partly transferred from central government to local authorities and/or pupils. This is particularly true in the case of reception costs (purchase of the receiver, cassettes, etc.).

b) The efficiency of the programmes actually implemented has seldom clearly exceeded that of traditional education

30. Internal efficiency: Evaluations of existing programmes do not systematically show better results than those obtained in traditional education. Close analysis of these trends shows that only programmes that have been the subject of long and well-planned preparation yield satisfactory results. In particular, the organisation and even the curriculum must not copy those of traditional education but must be tailored to the medium used.

31. The analysis also shows that where better results are obtained, they are at least partly due to greater motivation on the part of pupils rather than the intrinsic superiority of the programme. The efficiency of distance learning is very limited if minimal personal contact is not maintained between students and teachers and among students. This is due to the non-interactive nature of these media, which merely transmit a message.

32. External efficiency: Under the traditional system of education diplomas are issued which carry a certification power recognised both by the law and by employers. Distance learning cannot compete with traditional training unless its certification power is recognised, hence the problem of equivalence.

33. New types of public: Distance learning is sometimes the only possible way of supplying education to certain groups (such as highly scattered populations in remote areas, people working full-time, and persons physically unable to move for health reasons). In this case, comparison with the cost of traditional education becomes meaningless, but the technical methods used are possibly not, or no longer, the best possible.

3. Potential Efficiency of NIT

34. The semi-failure of "modern educational methods" can be explained by two factors:

i) They were often tacked on to a traditional system which was not ready to assimilate them, or an attempt was made to copy traditional school methods in home study programmes.

ii) They lack flexibility and interactivity. In order to simplify design and achieve savings, the system selected was usually based on a single medium. The message was heard and/or seen by the students in a passive manner. Even when it could be recorded to be reheard or reseen at the students' convenience, it was not possible to put questions directly to the author. In most cases it was necessary for a teacher to act as an intermediary but this might prove fruitless if the teacher had not designed the message himself.

Any improvement, diversification or adjustment of the system usually turned out to be very expensive. Potentially, new information technologies largely escape the second criticism and may prevent the first more easily than the previous generation of new education methods.

35. The supporters of NIT actually attribute three decisive (in their eyes) advantages to them:

i) They can improve the efficiency of the traditional school thanks to their interactive nature and the multiplier effect of using several media simultaneously;

ii) They can permit the provision of many types of training outside the framework of the traditional school, from home study aimed at a diploma or professional advancement to tailor-made self-teaching systems;

iii) They constitute a relatively inexpensive solution to present education problems.

36. It is therefore essential to examine more closely the available data on the costs and effectiveness of NIT to see whether, and under what conditions, in which fields and at what probable future date, they can in fact provide an economic solution to the problems of education.

Chapter II

THE COST OF NEW INFORMATION TECHNOLOGIES IN EDUCATION

37. Even if the introduction of NIT in education appears necessary in view of present technological trends and social changes, the fact remains that budgetary constraints prohibit the use of innovations which would involve substantial additional expenditure. This is why the supporters of these new technologies insist on the budgetary savings which, according to them, they should bring about and why governments are anxious to have reliable data on the financial consequences of deciding to introduce computers in schools on a large scale. Unfortunately, it is impossible to provide a precise evaluation of the cost of an educationl system based on NIT.

There are four reasons for this:

i) The hardware is not standardized and costs vary greatly from one type or country to another;

ii) The data available on direct costs are provided in a form which does not generally permit either economic interpretation or direct comparison with the cost of traditional education;

iii) It is well known that the costs of most of the components of media-based teaching systems are changing at rapid but unequal rates, so that extrapolation on the basis of available data is subject to a large margin of error;

iv) The costs induced by this structural upheaval have hardly been explored at all to date.

38. At this point it would therefore be futile and dangerous to try to provide an economic evaluation of costs and likely future trends. On the other hand, it is possible and useful to do two things, first, describe the methodology that should be used to measure costs and the prolems encountered in obtaining figures and suggest ways of overcoming these problems and, second, take stock of existing data and show to what extent, if handled properly, they can provide some of the answers to the questions raised.

A. MEASURING COSTS -- METHODS AND PROBLEMS

39. The production function does not take at all the same form in a traditional education system as in one based on new technologies. In the first case, the essential factor of production is skilled labour, while in the second technological capital takes on great importance. This has three consequences for costs and their structure, and hence on their measurement. First, fixed costs are of much greater importance in the technology-based system so that the trend of total costs varies with the size of the system according to a law very different from that of the traditional system. Second, the breakdown of costs into their component parts has to take account of the different phases involved in the technology-based system. Third, the units of measurement cannot be the same as for traditional education.

40. The relationship between cost and budgetary expenditure is not the same in the new system as in the old. First, the opportunity costs are different and second, the adoption of a system based on modern technologies may involve a substantial shift of the cost burden from one group to another.

1. Form of the production function in an education system based on modern technologies and its impact on cost structure and trends

41. In the traditional education system the teacher occupies the central role, teaching aids account for only a small share of total budgetary cost and the duration of teacher-pupil contact is institutionally fixed as the same for all. The most important cost component to be analysed is therefore teacher salaries and the reference unit is the pupil.

This is not the case with a system based on NIT.

42. The consequences of the relative rise in fixed costs are as follows: The fact that most of the components of a system are acquired and paid for at a point in time and supply their services over several budgetary periods thereafter does not constitute a major problem. From the economic cost measurement standpoint it is easy to convert the purchase price into an annual rent over the lifetime of the equipment. From the standpoint of budgetary expenditure, all that is required is to stagger the introduction of new equipment and plan replacement purchases so as to avoid the "concertinating" of expenditure which would make the overall budget fluctuate drastically from one year to the next. The important point is that the costs of the different components of a technological system tend to vary less than proportionally to the number of pupils. This implies in fact that the comparative advantage of an NIT-based system with respect to a traditional one increases with size, so that there is little chance of there being any cost advantage as long as only small target populations are involved. It is therefore important to analyse in more detail the laws governing trends in the different cost components with respect to the size of the system. For this, however, it is first necessary to determine the most appropriate way of breaking down total cost.

43. There is need for a cost breakdown according to technical criteria. In the traditional system an economic classification with total, average and marginal costs, on the one hand and fixed, proportional variable and non-proportional variable costs on the other suffices because the factors of production used are relatively homogeneous. In the system based on NIT, the

fact that the system requires technological media between the sender of the educational message and the receiver means that the costs of the different stages through which the message passes before being received have to be examined.

44. A distinction can thus be made between:

i) The cost of designing and producing the message (i.e. getting it on to a machine-readable medium). This is a fixed cost in the sense that it remains the same regardless of the number of people receiving the message;

ii) The cost of transmission. The laws governing changes in this cost depend on the mode of transmission. If it is by an electromagnetic system (telephone line, radio or television broadcast), the cost is proportional to the time taken for the transmission, but does not vary according to the size of the audience;

iii) The cost of reception. Reception involves devices (television screen, computer memory, tape recorder, videorecorder, etc.) that can serve only a limited number of people. The cost therefore increases with the size of the audience, but stepwise and not proportionally.

45. The overall cost of an NIT-based system thus increases with the number of pupils, but less than proportionally, so that the cost per pupil tends to fall. But what interests us is the cost of supplying a given educational service, so that a lot depends on the time taken for the message to be assimilated.

46. New technologies have an impact on the time taken to transmit knowledge. In the traditional system, the duration of the different educational programmes is generally laid down for all establishments by regulations. The time for transmitting a given educational message is thus fixed in advance on the basis of experience of the efficiency of the traditional method of teaching through direct contact between an instructor and a group of pupils. The introduction of methods based on new technologies may enable this time to be reduced if, as claimed by the supporters of such systems, the student is able to assimilate the material more rapidly and requires shorter contact time with the teacher. In this case the economist is not interested in the annual cost per pupil but the cost of transmitting a programme. If it is desired to compare NIT-based programmes (provided that they are considered to take the same time to assimilate) the best unit of measurement is the pupil-hour. If it is desired to compare an NTI based with a traditional system the most suitable unit is the cost of the programme per pupil.

2. Cost, Expenditure and Financing

47. As was seen in Chapter I, budgetary expenditure is not to be equated with cost as the latter has to include the opportunity cost which has to be added to that of the resources used. This distinction is particularly important in the case of a system based on new technologies. It is also

important to determine who has to bear these costs, since those who pay are not exactly the same in the two systems.

48. There are differences in cost between the two systems. Education economists have often pointed out that a substantial share of the cost of studies from the standpoint of the individual is foregone earnings. This is particularly true in the case of courses for adults when they are held during normal working hours. It has in fact been calculated that in a "traditional" cycle this could account for over 95 per cent of the total cost. To the extent that the use of new technologies may on the one hand enable the total training period to be considerably reduced and on the other, thanks to its flexibility, enable the training to be organised mainly outside working hours, there should be a very marked reduction in the total cost of the training cycle. However, the second factor may very well merely bring about a shift of cost from the employer to the employee, if the traditional cycle was at the employer's expense and the employee cannot persuade him to maintain this arrangement. As regards basic schooling on the other hand it is unlikely that the large-scale introduction of NIT in schools will reduce the duration of educational cycles. But if the effect of the current technological revolution on working time and job supplied is considered, it may be assumed that on the one hand the foregone earnings of school-leavers will be reduced because they are more employable and on the other that the new organisation will enable vocational training to be obtained at the same time as a formal educational qualification, which again should facilitate subsequent insertion in the labour market.

49. There may be several possible effects on the different payers. The public education system at present dominates in a majority of countries and is financed to a very large extent through government sources. Financing the technical equipment required by the new system may bring about a partial shift of the budgetary burden to three other payer groups:

i) In countries where financing is centralised it can already be seen that governments are tending to encourage local authorities to contribute to the purchase of equipment for schools within their areas;

ii) The use of micro-computers and video recorders by pupils encourages the private purchase of such machines by parents and later on by young adults who recognised the value of them during their studies, so that private manufacturers are generally prepared to supply educational establiishments at a reduced price. This practice is at present common in most Western industrialised countries;

iii) When such equipment is used in the context of distance learning, the cost is usually borne by the "pupil".

50. It is thus possible that in the future part of the financial burden of education will gradually shift from governments to other groups, and in particular to households. This insidious fashion of modifying the responsibilities of the state raises a number of problems. In order to make an accurate evaluation of the economic costs entailed in the large-scale use of new information technologies and calculate the total cost of education organised in this way it is essential to have reliable data presented in a

standardized way. Even if financial flows only are considered, it is essential to:

i) Calculate the budgetary cost per pupil of a clearly defined course or programme;

ii) Compare and monitor over a period the cost of different items of equipment valued at constant prices;

iii) Breakdown the total cost of technical equipment according to the phase of the knowledge transmission process;

iv) Identify the share of the total cost imputed to each payer.

These conditions are far from fulfilled at present, so that it is hazardous to try to draw general conclusions. It is neverthless possible to present a partial and approximate picture of the situation and (with due caution) indicate probable future trends on the basis of the available information.

B. DATA ON COSTS -- INFORMATION CONTENT AND SHORTCOMINGS

51. It is impossible to make any valid critical assessment of the available figures concerning the total cost of modern technology-based education without prior examination of first, the available data on the different components of this cost and, second, the way these data were derived and presented. We shall therefore first review the cost evaluations of the different phases of providing individual customers with the "educational message" and the medium-term future projections of these costs. Only then will we proceed to a critical examination of total cost and try to establish whether it is possible to determine reliable unit costs.

1. Cost of the Different Phases of Transmitting the "Educational Message"

52. Taking the distinction made in the first part of this chapter between the production, transmission proper and reception phases, we shall examine in each case the existing data available on the component parts of the technical system used and discuss their reliability, passing from evaluations based on observed reality to forward studies of anticipated future trends. It must not be forgotten, however, that new technologies will not totally or immediately replace traditional inputs, in particular teachers. In a second stage we shall therefore try to assess the impact of the introduction of NIT on these traditional components of education costs.

53. The cost of new technologies:
The phase of producing the "educational message" can theoretically be broken down into two stages, the development of an educational programme and its reproduction on a storage medium, generally for use with a computer. In practice it is difficult to disassociate the two stages because the constraints imposed by the medium determine not only the form but also, at least to some extent, the content of the message. We shall thus examine the cost of producing educational software.

54. The costs are mainly wage costs. It is in fact generally agreed that the production of efficient educational software requires the participation of a fairly considerable number of people with different skills:

i) At the programme production stage, an author is responsible for the design and for writing accompanying texts; an education expert puts the work into appropriate form; a programmer codes the material according to the instructions of the first two; a graphics expert is responsible for graphics, layout and presentation; lastly a marketing expert studies the potential market and adaptation of the product to the market. The time spent by the first two persons (or groups) can be evaluated fairly accurately, but this is not true of the others, as everything depends on the general design of the programme. Similarly, wages vary with the supply and demand situation. It can be assumed that programmers' wages will be high because they are at present scarce on the market;

ii) At the reproduction stage it is necessary to distinguish between the cost of copying discs or tapes, that of printing the documents, texts and instructions and that of preparing a model packing and reproducing it. The cost varies with the length of the documents and the number of copies required.

55. Evaluations of total cost are few and far between. What is more, it is difficult to compare them because they do not use the same reference unit. One United States estimate indicates a minimum of $100 000 (of which $30 000 for the designers' wages) for the design and production of a one-semester course, a cost which could reach $150 000 if interactive video discs were used. Another United States estimate (3) indicates that we have to reckon with $15 000 per course unit and each teacher needs 100 units per year, which seems to indicate a cost of $750 000 per semester. A French study (4) gives a figure of FF 50 000 to FF 200 000 per hour of CAI. If a semester course is asumed to represent 60 to 100 hours of instruction, the price ranges from FF 3 to FF 20 million or between $2.5 million per course. It is thus difficult to draw any precise conclusions from figures that apper to be not strictly comparable. In any event, however, while these sums appear very high, the unit cost is in fact very low if the same course is given to hundreds of thousands of pupils and can be used for several years. Likely future cost trends are even more difficult to determine. It is nevertheless likely that the costs indicated above will not change very much since we are concerned with evaluating the cost of a high quality software package and not with measuring the cost of existing packages. Wage costs will probably tend to increase and the scope for reducing technical production costs will be fairly limited. If there is to be any significant change as compared with educational software at present in use, it is more likely to take the form of improved quality -- this being still very mediocre in most cases (cf. Chapter III) -- than that of a reduction in unit cost.

56. The transmission phase is that in which the educational message travels from the place where it was produced to that where it is received. Evaluating the cost here, evan approximately, is even more problematical than in the production phase because it varies enormously according to the type of transmission, which in turn depends on the technology used and its level of development. In order to throw more light on the question a distinction can be

made between on the one hand the transmission of a computer programme and on the other that of audio-visual documents. In both cases two extreme solutions are conceivable. If the computer programme and accompanying instructions have to be transmitted from a central computer to a terminal via a telephone line the cost depends on the time of transmission and can be very high. If it is desired that the programme be truly interactive, i.e. that the pupil be able to communicate with the machine in real time, it is necessary first to occupy a telephone line during the whole duration of the "lesson" and second to pay at the highest rate because teaching usually takes place during normal working hours (5).

57. The estimates range from about $1 300 per hour for a teleconference with ten participants scattered over the five continents to about $15 for the vidionet system in the Netherlands and $6 to $12 for the Plato system. Future trends will depend on telecommunications costs which are not likely to fall in the near future but could drop substantially in the longer term, especially if, as may be expected, preferential rates are granted for education. If, on the other hand, the programme can be run locally from a disc, the transmission cost is limited to that of sending the disc and is thus negligible when divided by the number of students. The same is true for the transmission of audio-visual documents. If these have to be broadcast the cost is that of using the transmitter for the duration of the lesson. A Dutch study puts this at $1 340 per hour. If the programme has been recorded on video-disc, the transmission cost is again negligible except in the case of a single student, but even in this latter case is still relatively low. There is not likely to be any major change in this cost component which in any case is very low per pupil.

58. The reception phase is that in which the message is decoded and presented to the pupil. The cost is mainly that of the equipment. Modern education systems using new information technologies are based on the computer. At the present stage two types of organisation coexist. First, a mini-computer with terminals and second, micro-computers each serving a group of pupils and possibly being able to communicate with one another. This distinction is likely to become irrelevant in the near future because of constant improvements in micro-computers which can already perform the functions of minis. We shall therefore consider only cost studies dealing with micro-computers.

59. This is the field in which the data are most plentiful, most reliable and most consistent. According to the type of hardware, the cost ranges from a minimum of $300 to a maximum of $6 000, with an average price for a machine with the generally accepted minimum level of performance costing between $1 000 and $2 000. It is generally considered that this cost, which has halved every two years since such equipment first appeared, will continue to do so for at least another four years. Certain authors even expect a cost of $100 in 1990 (6). More detailed studies, such as that by Jacob Schwartz (7) put the 1990 price at $300, but this is because they consider that the production cost has to be multiplied by at least three to obtain the selling price.

60. An analysis of the different components making up the price of a micro-computer, however, shows that these forecasts may be over-optimistic. The price can in fact be broken down into three roughly equal parts (8):

i) Technical manufacturing costs plus the manufacturers profit. The integrated circuits (central processor and memory) probably account for less than 10 per cent of this item, while the disc storage accounts for 30 per cent, assembly 10 to 15 per cent and ancillary equipment (power supply, chassis and housing, keyboard) 20 to 30 per cent. As labour accounts for a substantial share of the cost of these last components and opportunities for technical improvement seem more limited than is the case with integrated circuits, the conclusion must be that the scope for further cost reductions diminishes as the relative share of integrated circuits falls;

ii) Development costs in the broad sense (R & D, marketing and promotion) plus overheads. The prospect of any reduction here is even more remote than for the first category;

iii) Marketing costs, including the retailer's profit. With the expansion of the market and increased competition between producers these costs may fall a little, but certainly not much. It is nevertheless possible that for the sales promotion reasons mentioned above this cost may be low or zero for education establishments.

61. There are thus grounds to believe that the scope for further reductions in micro-computer prices is being exhausted and prices are closer to levelling off than is thought by the authors of the above-mentioned studies. This view is supported by another observation. Price trend forecasts are based on a given type of equipment and marketing organisation. The fact is, however, that when a new, more powerful model is launched on the market the earlier one is soon withdrawn from sale. The trend is thus not so much towards a reduction in the price of equipment with more or less stable performance but more in the direction of significantly improved performance at a more or less constant price. An improved cost/effectiveness ratio is thus much more likely that an abortive reduction in cost (9).

62. The hardware does not consist of the central processor only. Other major components are:

i) Fast memory: present cost is estimated at $1 000 per megabyte and is expected to fall considerably by 1990 (10) but it is also considered desirable that capacity should be increased to eight megabytes which would keep the cost at about $2 000 while multiplying capacity by four and thus permitting very high quality graphic reproduction and considerably simplified programming.

ii) Mass storage (slow memory) enables a great quantity of information to be stored and used as required. Prices per unit capacity are likely to fall substantially, but this will probably result in a dramatic increase in capacity for slightly lower cost;

iii) Reader costs at present vary according to type of storage (tape cassette or floppy disc), but the advantages of the floppy are such that tapes are likely to drop out of use. The use of a floppy disc unit is at present estimated at about $1 000 and that of a much improved version at $500 by 1990;

iv) Display screen: currently estimated at $400 to $600 the price is not expected to fall much by 1990;

v) Other hardware: this concerns audio-output devices, especially of language emitted by the machine, interfaces, etc. No significant price falls are expected. J. Schwartz puts the cost of a standard facility at $550 by 1990.

63. All this hardware requires maintenance and repair however. The maintenance cost for "traditional" equipment (computers, language laboratories, etc.) is already high. As regards the different components of the new integrated systems, it seems that maintenance will continue to be an important cost item. According to a French source (11), maintenance costs already exceed the cost of hardware depreciation and are likely to increase, at least relatively, in the future. A United States evaluation of the Plato system, although lumping software and maintenance costs together, seems to arrive at a comparable figure (12). These costs could be significantly reduced if manufacturers were willing to alter equipment design so that servicing is reduced to tasks of low technical content that could be carried out by the user (changing cards or modules) (13). Such a development appears unlikely, however, because of the vested interests of repairers on the one hand and manufacturers on the other, the latter preferring to be able to offer cheaper equipment in the hope that users will not hesitate to replace it in the case of breakdown.

64. The overall cost trend for these new technologies is thus a downward one, though this is much less marked when all the different components are examined separately than when attention is concentrated on the central processor. But these technical resources will not, in most cases, replace the traditional inputs and especially teachers. As these latter account for by far the greater part of the cost of traditional education it is essential to try to forecast the likely future trend here.

65. The introduction of new technologies will have an impact on wage costs. The production and maintenance of the hardware making up the new technical systems used in education gives rise to significant wage costs. As seen above, in every case where wages account for a significant share of the cost of a component, no significant price fall is to be expected. This is particularly true of maintenance but can also be seen in the mechanical parts of the hardware and in assembly. Secondly, using NIT generally leads to the recruitment of new staff -- technicians, programmers -- who usually receive fairly high wages, the cost of which is virtually never included in new technology cost evaluations. It is therefore essential to take account of this item which is very likely to significantly increase total cost and reduce its tendency to fall over time. Lastly, and above all, in most cases the machines do not completely replace teachers.

66. In the traditional school no significant fall in wage costs is to be expected. On the contrary, there are indications of an upward trend. As seen above, a number of technicians are recruited alongside the teachers in schools where NIT are introduced on a large scale. The teachers themselves need substantial retraining before they can make effective use of these technical resources. This retraining has to be on a large scale and the cost is very high. In 1983-84, for example, the French Government spent FF 200 million on training 20 000 teachers, which represents FF 10,000 or $1 250 per teacher.

What is more, wherever the teachers are defended by strong unions it can be expected that the latter will claim wage increases to reward the increased level of qualification. Lastly, contrary to what is commonly claimed, the need for teachers is actually likely to increase. The hypothesis generally put forward is that in the new system the pupils spend part of their time with the machine in small groups and do not need the teacher's constant supervision. The teacher should not only be able to free himself from the least interesting tasks (see Chapter III) but can also look after a bigger number of pupils. Staff-pupil ratios could therefore fall, and with them wage costs. This optimistic assessment, however, needs to be tempered at least in the short term by the following considerations:

i) First, in most countries teachers are covered by a contract that protects them against redundancy. The only way of reducing numbers would thus be a lower rate of recruitment or even non-replacement of teachers retiring or leaving the profession for other reasons (resignation, death, etc.). The effects would be felt only very gradually even in the best of cases -- if the education system were expended rapidly. The effect is likely to be minimal in a period of falling student numbers;

ii) Second, teacher's claims for improved staff-pupil ratios are strong enough for the authorities (or elected bodies administering schools) to be reluctant to take any measures appearing to go in the opposite direction;

iii) Third, the new technologies require pupils to work in small groups. As long as the optimum level of equipment has not been reached in schools the time each pupils spends with the machine will remain short and the scope for economies will be limited. Even in fully equipped establishments, scarcely any more than half an hour of individual contact per day is planned, so that the pupil is in contact with the teacher for by far the greater part of the time.

iv) What is more, working in small groups can in certain cases necessitate much higher staff-pupil ratios. This is particularly true at primary level, where pupils need constant supervision, and in higher education, at least in those countries and disciplines where most of the teaching was formerly done by lecturing to large numbers of students. Where one lecturer could give a course to two or three hundred students, four or five times as many will be needed to supervise one hundred groups of three.

67. If care is not taken, the large scale introduction of NIT in education is thus likely to substantially increase total costs in the next few years, mainly because of higher wage costs. This is obviously not the case with distance learning, in particular adult training, where wage costs can be reduced considerably by completely doing away with a tutor. Even in traditional education, it is likely in the longer term that the presence of the new equipment and pressure by pupils will oblige the system and those in charge of it to reorganise fairly drastically and this could result in significant wage cost reductions. At present, however, nobody can forecast how long it will be before such an effect comes about or how far it will go. On this basis is it possible to measure the total cost of a system using NIT

and compare it with the cost of a traditional education system?

2. Total Cost Calculation and Comparison -- Problems and Limitations

68. First of all, it is worthwhile giving an idea of the size of the investment involved by exmining the rate of introduction of new equipment into the school system. We shall then take the example of one of the rare systematic and reasoned evaluations available to show the degree of uncertainty that still remains in this field. Lastly, we shall try to see whether it is possible to make a comparison with the cost of traditional education.

69. The investment effort is considerable, as can be seen from a few figures. The average annual increase in the number of microcomputers in education establishments between 1979 and 1983 was:

- -- 89 per cent in France;
- -- 74 per cent in Germany;
- -- 58 per cent in the United Kingdom;
- -- 49 per cent in the Scandinavian countries;
- -- 61 per cent in the other West European countries;
- -- 42 per cent in the United States;

In this last country 325 000 microcomputers (14) were installed in schools during 1983, 14 6000 in Germany, 9 400 in the United Kingdom, 7 600 in France (where there should be 32 000 by 31st December 1984), 400 in Italy, 4 400 in the Scandinavian countries and 6 900 in the rest of Western Europe. A similar effort (though varying from one country to another and unequally distributed as regards level of education) is found in all OECD Member countries (15).

70. This effort should be maintained in the years to come. France, for example, plans to have 100 000 micros installed by 1988 and a US study gives a figure of 1 250 000 for the United States. Despite this effort, however, the level of equipment is still far from the minimum required for the efficient use of these new technologies. In the United States, the leading country in this field, 62 per cent of elementary schools have been equipped, but the majority of them have only one microcomputer. At secondary level, 83 per cent of the establishments have at least one micro but the proportion that can allow all their pupils to use the machine for at least a quarter of an hour a day is very low. In order for each pupil to have 20 minutes machine contact a day, which appears to be the minimum to be any use, A. Melmed (16) has calculated that 2 500 000 microcomputers would be required. In order to reach this figure by the end of the decade the rate of acquisition would have to be doubled during a further two years (it has already increased by a factor of six in three years) and subsequently be maintained at a level of 500 000 a year, i.e. over twice the present stock. In the case of France, the installed stock at the end of 1983 was 11 000 machines and the figure is planned to rise to 100 000 by 1988. For each pupil to have 20 minutes contact per day over 600 000 would be required. These overall figures concern only the computer

part of the essential integrated system. The stock of peripherals (high definition screens, videodisk readers, fast memories, etc.) is even more inadequate and, as we have seen, improving the equipment rate will increase costs much more than micros. Furthermore, some of the computer equipment now installed is totally inadequate for the tasks required of NIT and will have to be replaced by more powerful hardware. A considerable effort has therefore been made but it needs to be maintained for at least five to ten years, depending on the country, in order to reach the critical mass.

71. Problems are encountered in the evaluation of total cost. It is pointless to try to present the different evaluation studies available as they concern situations that are too different, use methodologies that diverge too much and have degrees of coverage too unequal for any valid conclusions to be drawn. On the other hand it is possible to derive some interesting pointers from a critical examination of an evaluation carried out with the necessary minimum level of rigour and exhaustiveness. The example taken is that already mentioned of Arthur Melmed for the United States (17). As the average cost of a microcomputer is estimated at $1 000, the rise in equipment indicated by the author would involve an expenditure reaching a ceiling of $500 million a year at the end of the decade.

72. At the same time, expenditure on software and courseware should increase to between $100 and $200 million a year. Details of the calculation are as follows: In order to be in contact with the machine for 20 minutes a day throughout the twelve years of primary and secondary schooling, a pupil needs 720 hours of educational software. But since pupils' needs are not the same in different subjects, this figure needs to be multiplied by a factor of 4 to 6 which gives a total of 3 000 to 4 000 hours of software per pupil. If the average cost of production of one hour of software is estimated at $30 000 and its average life at 5 years, the average annual cost is between $90 and 120 million. Taking account of the rapidly changing needs and rising minimum acceptable standards, it can be assumed that the average life of courseware is likely to fall to 2 1/2 years, which would bring the average annual cost up to something like $200 million (18). A. Melmed's conclusion is striking -- if this total expenditure of $600 to $700 million is compared with the total primary and secondary education budget of $140 billion, it can be seen that the large scale introduction of NIT's would increase this budget by only about 0.5 per cent. Even if the margin of error in this evaluation of total cost was as much as 50 per cent, the total increase would not be more than 1 per cent. For purposes of comparison, an average 3 per cent increase in teachers' wages would represent a comparable percentage increase in the total budget.

73. This evaluation raises several types of problems:

i) While showing that the cost of new technologies is almost negligible compared with the total budget, it seems to conclude that no savings are to be expected in other budget items so that total cost will increase, although only very slightly, with the introduction of NIT;

ii) The cost evaluations presented are open to criticism. According to the degree of optimism or pessimism with regard to future microcomputer unit cost trends and minimum acceptable performance levels, the forecast unit price for the end of the decade ranges from $100 to $2 000. For the reasons explained above, we are personally inclined to expect a figure of between $1 000 and $2 000, hence higher than Melmed's. The evaluation of software costs is open to similar criticism. According to the assumptions the estimate can range from half Melmed's figure to three or four times as much;

iii) The evaluation is very fragmentary. It does not appear to take account of any hardware except the basic mircocomputer. If peripheral storage, readers, interfaces, etc. are added, the hardware cost is easily multiplied by four. It does not specifically include maintenance costs which are high and are not likely to evolve in a favourable direction. Lastly, it does not take account of the possible need for improved staff-pupil ratios caused by the introduction of NIT. If this is the case, A. Melmed's demonstration, in drawing attention to the dominant role of wage costs, leads to the expectatio of a much more marked increase in total cost.

74. In considering the possibility of comparing an NIT based system with a traditional education system, a distinction has to be made between two cases. First, the introduction of NIT in teaching establishments to help with basic education. Second, the use of NIT to provide training for groups who, for various reasons, are not able or willing to attend traditional establishments. In the first case (at least in the short and medium term) no radical changes are to be expected in programmes or the organisation of teaching. This means in the first place that the duration of education cycles is scarcely likely to be changed. It also means that even in the best of cases the number of teachers can fall only very slightly and very gradually. There are in fact very strong pressures for the improvement of staff-pupil ratios, especially at primary and higher education levels, and also for increased teacher salaries. The cost of hardware is impossible to estimate without a very large margin of error, but it is clear that at most it is likely to represent only a few per cent of the total education budget.

75. All in all, it is more logical to expect an increase in total cost over the next few years rather than decrease, but this will depend on policy with respect to staffing, target equipment levels and hardware utilisation times. In the case of distance learning on the other hand, the cost can be much lower than in the case of comparable traditional education because this method of teaching allows wage costs to be cut very substantially. If it is wished to improve our knowledge of this field where much remains to be desired, more in-depth cost studies are required, with standardization of methods and reference units, together with longitudinal studies of experiments at present under way.

Chapter III

THE EFFICIENCY OF NEW INFORMATION TECHNOLOGIES IN EDUCATION

76. Many people, like the members of the Carnegie Commission, hold that the application of modern technology constitutes the fourth revolution in the field of education, after the appearance of the school, of written material and of printing. This view is based on the conviction that the use of these technical resources makes it possible to do what was already done in the schools much better, and to do much more, and that this will be even truer in the near future. This enthusiasm, however, is based to a large extent on a rosy view of the future. There is in fact a big gap between the progress hoped for from the use of NIT and that already recorded and objectively measured. This gap is partly due to the fact that information technologies are evolving very rapidly and their present potential is far from being fully exploited, but part of the problem is also that the supporters of NIT tend to have an over-optimistic view of their practical effectiveness in the face of institutional and human constraints. Lastly, some potentially negative effects of this technological revolution generally tend to be passed over in silence or minimised.

77. It is therefore necessary on the one hand to examine the established facts as determined by the evaluations so far carried out, and on the other to logically discuss assertions which have not yet been tested, either because the applications concerned are too recent or because they have not yet been implemented. It is also necessary, however, to try to throw light on some effects that have so far been discussed little if at all, particularly as regards the external efficiency of NIT-based education systems. This section reviews in turn improvements in the efficiency of traditional school tasks, the possible extension of these functions, and the external effects.

Section 1:

INCREASING THE EFFICIENCY OF THE TRADITIONAL EDUCATION SYSTEM

78. The advantages claimed for the introduction of NIT in schools have been more or less well documented by evaluation studies and the findings are more or less in line with the claims.

A. THE SUPPOSED ADVANTAGES OF NIT

79. These advantages concern first of all pupils, who are supposed to have improved acquisition rates and more positive attitudes. They also concern teachers, whose role is made more interesting while the task of evaluation is made easier. Lastly, they also concern the management of educational establishments.

1. The learning process is facilitated and accelerated

80. The interactive nature of the system allows each pupil not only to correct his errors but to understand why he made them. A new point in the programme is not introduced until the preceding one has been assimilated. At the same time, this enables each pupil to proceed at his own rate and thus not suffer from the slowness of others if he learns quickly and not to hold up the class if he has problems. By forcing the pupil to concentrate his attention, the machine encourages faster learning than the traditional class, thus, in the final analysis, allowing both the acquisition of more knowledge and more free time in a given period. Lastly, the logic and precision of the language that has to be used with the machine means that a certain discipline has to be developed in the presentation of ideas and the formulation of questions and answers and the faculty of abstraction is improved.

2. The pupil's interest in school is increased

81. Most teachers complain about the general drop in the pupil's level of interest in lessons. This is frequently attributed on the one hand to competition from the media, which offer a great deal of information competing with that the teacher is supposed to impart and present it in a more agreable way, and on the other to increasing heterogeneity of classes resulting from the democratisation of education, which constitutes a handicap for the pupils coming from cultural environments furthest away from that of the school, who get discouraged, especially if they are shy and are afraid of asking for explanations. An interactive computerised system in the first place enables those who have difficulty in expressing themselves in writing or orally to get over their problem since the machine does not ridicule or reprimand, but simply corrects. It enables the shyest to express themselves and the cleverest to demonstrate their talent. It also enables pupils to get involved in school work thanks to some of the exercises being like games, thanks to the abundance of information the machine can provide very quickly and, lastly, thanks to many pupils making it a point of honour to master the machine and get the better of it.

3. Teachers' assessment tasks are eased

82. Correcting exercises is a tedious task and takes up a lot of time. The same is true of recording marks and overall school performance. Using computer methods means that at least some of the exercises can be corrected and a fair copy supplied by the machine. It also means that the whole of a pupil's marks since he started school can be stored and makes it very easy to calculate class averages and the dispersion of marks, compare different

classses, etc. Analysing results in this way may in turn enable anomalies to be detected and corrected.

4. The teacher can devote hmself entirely to "noble" tasks

83. The muchine can easily replace the teacher for repetitive and boring tasks such as the dictating of exercises, words or symbols to be memorised and checking that they have in fact been learnt. It enables part of the class to be occupied, giving the teacher more possibilities for individual contact, so that he can help pupils develop their reasoning powers, adjust his teaching methods according to individual problems and shortcomings, etc. It also enables the teacher to vary the centres of interest and stimulate pupils' desire to learn by calling on more varied sources of documentation and letting them do additional exercises when it suits them.

5. The management of teaching establishments is facilitated

84. The computer's information storage and processing capabilities permit not only the management of examinations and marks but also student records and the establishment of timetables, jobs that normally not only take up a lot of teachers' time but are also not always very efficiently performed by these people who are not trained for such tasks. The advantages expected here are obviously considerable. It is necessary, however, on the one hand to check that they actually exist in specific situations, and on the other hand to be aware of the conditions that have to be met for them to materialise.

B. THE FINDINGS OF EVALUATION STUDIES

85. Evaluation studies have been mainly concerned with knowledge acquisition, this being the easiest thing to measure. Information is also available, however, on pupil attitudes and, though much more rarely, teacher reactions.

1. The effect of new technologies on knowledge acquisition

86. Most evaluation studies have been carried out in the United States, partly because there is already a certain amount of experience in this country and partly because the attitude of innovators is more favourable to external evaluation. Most studies are concerned with computer-assisted instruction. The findings are very much in agreement, despite the sometimes substantial differences in the magnitude of the observed effects. They show:

i) Improved results, particularly in scientific disciplines. The average improvement recorded in mathematics, for example, is of 0.4 standard deviation at primary level and 0.3 at secondary level, but only 0.1 in first cycle tertiary (19). Evaluations by comparison with control groups (20) have shown progress in mathematics by primary pupils of the average level of the control group in the 64th percentile of this group at the end of one year, in the 71st after two years and in the 76th after three years. These effects were even more marked if specific tests for each course were used instead of standardized tests. There also seems to be positive effects in reading, spelling, grammar and drafting, but they are not so clearcut and, above all, they hardly seem to continue after the first year (21);

ii) A substantial increase in the speed of acquisition. The time saved is considerable in all subject areas, the recorded results ranging from 33 to 80 per cent;

iii) There is a very marked difference according to whether the computer completely replaces traditional teaching or is used in a classroom situation. The positive effects seem to be much less apparent in the first case. A Norwegian study (22) confirms the findings of some United States studies cited by S. Hartley (23);

iv) The positive effects are probably greater for recent than for older experiments, which would appear to indicate, according to J.K. Kulik and R.L. Bangert-Drowns, that teachers have learnt how to make better use of computer methods.

2. The effects on reasoning powers

87. This is more difficult to evaluate objectively than is the acquisition of knowledge. The studies are therefore far fewer and much more qualitative in nature. They nevertheless still indicate a positive effect especially as regards ability to solve algebra problems.

3. The effect on pupil attitudes

88. Here again evaluation studies are relatively few and far between. Some conclude that attitudes towards school are improved by the introduction of computers, but not very much (24), while others find a very positive effect on pupil interest, attendance rates and even the respect of premises (significant reduction in vandalism) (25). An experiment with young delinquents even indicated that the computer was the only way of stimulating interest in these young people, normally allergic to school, and making them take up their studies again. What is more, all studies show a marked increase in interest in computers and their applications after an initial contact with the machine, a factor considered very positive in a world where computers are bound to occupy an increasingly important place.

4. The effect on teachers

89. Some observers have pointed out that the majority of teachers do not participate in the development of programs and feel somewhat removed from the teaching and not really in control of it. The conclusion is that this represents a potential obstacle to the universal use of NIT in schools.

90. The findings of these studies are thus nevertheless generally positive and sometimes even very positive. But it must not be forgotten that, as

rightly pointed out by Ludwig Braun, "a substantial share of the technologies used have not been examined in depth; some have not even been evaluated at all. Even as regards the computer which has been used experimentally as a teaching tool for about two decades, the majority of the most interesting applications have been developed only very recently and have not been subjected even to preliminary evaluation" (26). It is thus difficult and even dangerous to use the evaluation of past experiments as a basis for assessing the present and above all future possibilities for NIT in education.

Section 2:

THE EXTENSION OF EDUCATIONAL ACTIVITIES THANKS TO NIT

91. Here there has to be much more reliance on innovators' claims because there are still virtually no evaluations. An attempt can nevertheless be made to identify the conditions that have to be fulfilled for these claims to become reality.

A. POTENTIAL ADVANTAGES OF NIT

92. Some applications are simple extensions of traditional activities, while others represent major innovations enabling teachers to do what was previously impossible within the budgetary constraints imposed.

1. NIT can substantially enrich traditional teaching

93. To the extent that an integrated IT system allows access to all available data banks and numerous audiovisual documents, the teaching of subjects like history, geography, natural sciences and even the physical sciences and literature, can be enriched and pluri and interdisciplinary approaches can be developed. It makes the teacher's job at once easier and more interesting, enabling him to always have up-to-date material and to choose among numerous illustrative documents. It also makes it possible to use the educational potential of broadcast television programmes by showing in class those that appear useful, enabling the pupils to understand them better and to comment on them. More fundamentally, access to these new tools indirectly causes a renewal of traditional teaching through breaking down barriers between disciplines and allowing teaching by goals (27). These powerful teaching aids also enable teachers to multiply teaching strategies, even more than does the computer alone. The use of educational games and simulations has already become fairly common. At class group level it is possible to compare theoretical models with real experience, give a better understanding of abstract concepts, etc. The teaching of writing can be enlivened by using word processors. The teaching can also be adapted to the needs of each pupil through forming small groups whose membership changes with the subject in order to take account of the strengths and weaknesses of each member. On the basis of his observations the teacher can much more easily adapt his methods to the reality of his class. He will also have access to

increasing numbers of models developed by researchers exploring the new possibilities offered by NIT.

94. Lastly, thanks to the large volume of information that can be stored on pupils and in particular their individual rates of assimilation and progress, these systems allow teachers to better identify the problems encountered and take appropriate remedial action. Through a feedback process this information should also enable the authors of interactive educational software to make improvements and compare the advantages and disadvantages of each method. New information technologies should therefore in principle greatly improve the efficiency and interest of traditional teaching, but they should also permit completely new methods.

2. NIT allow the development of teaching hitherto impossible

95. Thanks to the virtually infinite simulation possibilities offered by these integrated technological systems it is possible to represent and explain phenomena that cannot be handled directly. This is obvious for dangerous phenomena such as the internal operation of a nuclear reactor or when it is a matter of observing phenomena which actually occupy a time much too short or too long to allow direct observation. But this capability is also used in practice to economise on very costly experiments. The example of flight simulators and the considerable sums saved by airlines and air forces in pilot training is the best known, but is far from being the only one.

96. This new teaching may take place inside or outside the traditional school and, more generally, NIT should permit the development of a whole range of extra-school training.

3. NIT should permit the development of many forms of extra-school training

97. In the first place there is the case already mentioned of initial training outside the school thanks to distance learning. This is in fact the only way of supplying education to three types of public:

i) Seriously handicapped people who cannot travel regularly;

ii) Isolated people who cannot attend school because of geographical distance, difficult travel conditions or ethnic peculiarities that make integration into a "normal" school difficult or undesirable. It is certainly possible to conceive of boarding schools for such people but apart from the fact that this solution is likely to be extremely costly, there are many other disadvantages -- prolonged absence from home, the grouping of individuals who do not know one another and are not always of the same culture, etc.

iii) Those excluded by failure from the school system who want to take up their education again but do not have the time or the inclination to go back to school.

98. New technologies can greatly improve the traditional methods of distance teaching (correspondance courses, radio and/or television broadcasts, cassettes, etc.) thanks to their interactive nature which allows dialogue with the machine, a tutor and other pupils.

99. New information technologies are also an ideal way of developing training for adults. Retraining and refresher courses can be tailored to individual needs to the extent that many programs or simply up-to-date information on a specific subject area can be accessed through equipment in the home at a time to suit the user. They also enable the same program to be supplied to geographically dispersed groups that could be brought together only at considerable cost. They allow training activities to be run at the place of work in line with the needs of the firms or organisations concerned. Lastly, they can respond to many different types of demand not of a directly professional nature, thus facilitating access to culture for large segments of the population. When the extent of unsatisfied demand in this area is known, then the importance of this potential function of new technologies can be appreciated.

100. Lastly, NIT can permit the development of contacts and the interchange of information and opinions between individuals or groups interested in the same problems. The development of interactive man/machine communications should thus in fact enable human contacts to be improved and multiplied, rather than leading to the isolation of the individual.

101. The possibilities offered by these new technologies, so far exploited only to a very limited extent, are thus apparently very considerable, so that it seems quite justifiable to talk of a revolution and a discovery as important as that of printing. But it is important to remember, first, that at best this is a potential that needs a favourable environment to become reality, and second, that this potential is as seen by the supporters of new technologies, who are perhaps not always totally objective and may sometimes be over-optimistic, in particular through ignoring certain potentially negative effects.

B. EFFICIENT USE OF NIT -- CONDITIONS REQUIRED AND LIMITATIONS

102. Computerised instruction systems can be fully effective only if new technologies are introduced on a large scale, if they are sufficiently user-friendly and if they can be used to access information. What is more, the result will depend on how educational institutions and their members adapt to this major innovation. In addition, positive effects may be more limited than envisaged and unexpected negative effects could appear.

1. Environmental conditions required for effective use of NIT

103. Certain conditions need to be fulfilled by the technical instruments themselves. It may appear superfluous to say that these machines can be effective only if the pupils know how to use them, but it must be remembered that the critical mass of hardware is still far from having been reached in the vast majority of countries. As was seen in Chapter II, a very small percentage of establishments possessed even a minimum number of microcomputers in 1982-83 and, in most countries, the effort planned for the newt few years will not be enough -- often far from it -- to reach the minimum rate of equipment required for the really efficient use of NIT, particularly as a substantial proportion of the microcomputers at present in use are not

powerful enough to allow real interactive work and that other hardware has not developed as fast as microprocessors. There thus remains a very great deal to be done before all pupils can be offered all the possibilities opened up by NIT. As long as this level of equipment has not been reached, only a fraction of the potential of these machines can be used and there is a risk of creating dangerous inequalities between pupils and establishments if the equipment is unevenly distributed.

104. In the second place, efficient use of the hardware is possible only if there are simple languages to enable the pupil to converse with the machine and if very effective teaching software creates a truly interactive environment. The fact is that, as is well known, the first languages developed for computers required too great a capacity for abstraction and much too long a training for them to be accessible to all pupils of all ages. Considerable progress has been made but two serious faults still remain:

i) First, there is no simple universal language that can be used interchangeably on all types of machine. All too often the information contained on magnetic storage media cannot be directly transferred to a different type of computer;

ii) Second, even if there is confidence that one day -- soon we hope -- direct voice communication with the computer will be possible, this is still at present in the realm of science fiction except for very limited applications.

105. Educational software, too, is improving, but here again it can be seen that the increase in quality is by no means keeping pace with that in quantity. In the United States, for example, a recent study found that of the 4 000 teaching packages available there were probably only 3 or 4 per cent of acceptable quality. Another study found that even after careful prior selection the schools in one Long Island district still ended up with over one-third "junk" (28). This opinion seems to be shared by all the experts. The main reason is that, as pointed out by Y. Le Corre and J. Schwartz, educational software is at present mainly produced by "amateurs" (29). It is well known that the production of high quality educational software requires very varied skills and not only a good knowledge of the material to be taught and of programming. These skills cannot all be found in one individual so that it is necessary to form well-knit teams with each member contributing his know-how and being able to understand the problems and proposals of the others. We are thus still far from having the ideal type of software and full interactivity. There is still a long way to go before such systems become fully effective.

106. Thirdly, the efficient use of the computer/communications potential depends on free access to data banks and on the quality of these banks. If the teacher is to really enrich his courses, he needs access to precise, detailed and up-to-date information. He needs to be able to have rapid access to many more inconographic documents than are available in the manuals. It is therefore essential:

i) To have very complete and well-organised data banks. This is certainly not the case at present, most existing banks being relatively incomplete, covering only certain aspects of the information required for teaching, and difficult to assess.

Considerable progress has been made in the past few years, but much more is required in the near future if data banks are to make a real contribution;

ii) For educational establishments to have access to data banks and audiovisual archives free or at very low cost. The cost problem is connected with that of intellectual property and the legal aspects are complex. If these problems are not resolved, one of the major potential advantages of computerised education systems will not be fully realised (30).

107. Even if the hardware, software and information sources exist, however, the school system has to be organised to make use of them and teachers have to be willing to do so.

108. Certain conditions have to be fulfilled by the educational system and its members. The full potential of NIT cannot be exploited without profound changes in the organisation of the school system and its establishments. The optimum structure in an education system where the means of communicating knowledge, know-how and attitudes are the teacher's words and a piece of chalk is not necessarily well-suited for a system where new technologies occupy a central place. It is necessary to adapt the curriculum so as to integrate educational technology and just how this should be done is not yet fully understood. Earlier experience with audiovisual aids, generally under-utilised or poorly utilised -- if not just consigned to a cupboard -- because it was not known how to integrate them into teaching, should provide food for thought.

109. It is also necessary for the school to take account of the increasing number of home computers in order to guide parents in their educational uses and ensure complementarity with school work if the children's interest is not to be snuffed out by difficulty of access to the school computer or by its limited capabilities.

110. It is also essential that administrators and teachers be prepared to integrate these new systems into their activities. In any event, this implies first of all a very substantial retraining effort. This is an enormous task as large numbers of people are involved and there are still very few qualified instructors. It is therefore necessary to start by training instructors to train instructors before these latter can train new teachers and administrators and retrain those already at work. As we have seen, not only will this essential operation be very costly, but it will also take time, which will further delay the full effective use of these new technologies. Furthermore, there is a real risk of a lack of co-ordination between the acquisition of hardware and the training of staff and hence problems of adaptation for the latter if the hardware is not identical to that on which they trained.

111. Another condition -- all too often considered to be already fulfilled -- is that staff should be willing to exploit the potential offered by these machines. It has to be admitted that they revolutionise normal practices and call traditional teaching methods into question. They may very well be perceived as a threat, as occupying pride of place, performing the functions of the teacher who is now reduced, like a factory worker, to a machine minder. There are even grounds to fear that resistance may be greater

on the part of the majority of "good" teachers, who do well with traditional methods and perhaps do not see what real improvements new technology could bring to their teaching, than on the part of not-so-good teachers who might be only too happy to let the machine do what was previously their job. Hence the importance of proper retraining with insistance on the new opportunities for the teacher opened up by these new tools and the possibility of handing over to them at least some of the more routine and less interesting tasks.

112. It can thus be seen that harnessing the potential of NIT will not be easy. Difficulties will have to be faced and there will always be a substantial gap between this potential and the actual results obtained with the machines. It will also be necessary to guard against the development of unexpected negative effects.

2. Limits on and possible dangers of the large-scale introduction of NIT in education

113. Some of the positive effects claimed by the advocates of introducing NIT in education are by no means proven and/or it is even possible to put forward arguments to prove the contrary. What is more, certain possible negative effects are just not mentioned.

114. Greater equality in the conditions of schooling is by no means certain. It is claimed that using NIT enables shy pupils, slower ones, the handicapped, those rejected by the traditional system and those whose cultural environment is furthest removed from that of the school to improve their performance and approach that of the more favoured pupils. There is certainly evidence to support this theory, but these positive effects can be achieved only if:

i) Schools in poor districts are as well equipped and the teachers as well trained as those in rich districts. Some United Kingdom studies show that this is not always the case and that there is in fact a tendency to introduce new technologies to reduce costs in "poor" districts and to enrich teaching in "rich" districts;

ii) Advantage is taken of the possibilities offered by these instruments to provide remedial teaching for pupils who need it;

iii) Inequalities in home microcomputer ownership does not result in pupils belonging to such households tending to monopolise the school equipment through their being able to learn to use it quickly and efficiently.

115. It is also claimed that the introduction of NITs should make the teacher's job more interesting and free him from a number of routine and boring tasks. But this will be true only if all the possibilities of these machines are exploited by the school and provided the teachers are able and willing to use them. Two negative effects may develop:

i) Differentiation between teachers attracted by computer technology and enthusiastic about its efficient use and others, more attracted by direct human contact, who feel threatened and diminished by these machines;

ii) Differentiation between those who produce the software and develop new audiovisual "manuals" and those who are reduced to merely "accompanying" a message designed by others.

116. Lastly, it is claimed that the widespread use of NIT should favour exchanges and contacts between individuals. The fact is that nothing could be less certain. On the contrary, there seems to be a tendency on the part of individuals fascinated by electronic games and computers to become isolated from others. At best, the new contacts that develop are long distance ones through communications media and are not true human contacts. The machine tends to favour the development of intellectual capacities, sometimes at the expense of affective ones. In our opinion this represents a real danger and every effort must be made to combat it.

117. The internal effects of introducing NIT in education are thus potentially very substantial and for the most part positive, but this potential will not be realised automatically and certainly not immediately. What is the situation with regards to external effects?

Section 3:

THE EXTERNAL EFFECTS OF INTRODUCING NIT IN EDUCATION

118. This concerns the impact on the situation of people once they have been trained by these methods. A distinction is made between three cases:

A. TRAINING WITHIN THE TRADITIONAL EDUCATIONAL SYSTEM

119. Certification is in principle the same as in traditional education. When the two types of education coexist, all that matters is that potential employers should not differentiate between the two or should prefer NIT-based training. There can nevertheless be some hesitation and even rejection at first, especially if the methods are not yet fully developed. The precedent of the television education system in Ivory Coast, which has just been abandoned because of hostility on the part of parents, should be borne in mind.

B. TRAINING OUTSIDE THE TRADITIONAL EDUCATIONAL SYSTEM LEADING TO A DIPLOMA

120. Everything depends on whether the diploma awarded is recognised (either by the authorities or, where there are no national diplomas, by employers) as being equivalent to one awarded by the traditional education system. If this [illegible] the case, the external efficiency of this type of training is low.

C. NON-DIPLOMA COURSES FOR FURTHER TRAINING OR PERSONAL SATISFACTION

121. If the aim is personal satisfaction, the problem does not arise. If the further training is intended to provide additional skills recognised by the employer, everything depends on the latter's attitude. Prior agreement can ensure high external efficiency.

* * *

Conclusion

122. Potentially, the internal efficiency of educational systems using NIT is very high, but their practical efficiency is largely governed by the care with which the system is set up, and specially as regards courseware. At the moment, practical efficiency is still not very high, as confirmed in the preface to the consolidating report on the symposium held at Pittsburgh in March 1983 (Computers in Education: Realising the Potential), which states that: "The computer is perhaps the most exciting potential source of educational improvement in centuries. Although most currently available applications for schools are mediocre, the possibilities for significant uses are impressive." There is as yet no guarantee of external efficiency where the training leads to the award of a diploma, but in the other cases it is bound to be very high.

GENERAL CONCLUSIONS

123. At the end of this study it is perhaps worthwhile to recall the main outstanding problems and formulate some recommendations.

Outstanding problems:

124. Information about costs is fragmentary and not well-suited for rational economic analysis:

- -- Studies on the cost of NIT-based education virtually never use the same units of measurement so that their comparability is considerably impaired;
- -- The studies deal with a given point in time so that the information provided is often only of historical interest because of rapid changes in the price of some types of hardware. Longitudinal studies enabling forecast and actual costs to be compared and trends in the operating costs of a programme to be followed are sadly lacking;
- -- Some costs are infrequently and inaccurately measured. This is particularly true of maintenance costs and the cost of retraining teachers;
- -- There is ambiguity concerning the cost of microcomputers. It is generally difficult to know whether the figure given is the cost of production or the sales price and whether it covers the computer only or includes the peripherals.

125. The costs involved in adapting the school to the introduction of NIT are generally not measured:

- -- The costs of installing the equipment, including any modification of the premises, are virtually never mentioned in the studies;
- -- The operation costs of the installation are also rarely mentioned;
- -- The impact of introducing NIT on personnel costs is passed over in silence, despite its potentially great importance.

126. Future cost trends are estimated in an approximate and often biased fashion:

- -- Forward studies are generally based on hardware only;
- -- there is a marked tendency to extrapolate past trends without first analysing the causes of, and limits to, the falling costs observed in the recent past;
- -- The structural effects of large-scale introduction and their impact on costs are not mentioned.

127. The effects of introducing NIT in education are very unevenly documented:

- -- The impact on teachers has been inadequately measured;
- -- The effects on pupil attitudes have not received sufficient in-depth study.

128. There is an unfortunate tendency to confuse potential and actual effects:

- -- Extrapolating the results of the evaluation of pilot schemes -- well-endowed with resources and run by highly motivated groups -- to the whole of the education system is dangerous;
- -- Evaluation generally concerns situations where the minimum threshold for the efficient use of NIT has already been reached. The effects of having just one or two microcomputers in a school have not been seriously examined.

129. Certain effects are claimed but have not been empirically checked. This is true in particular of the equalising effect on pupils.

130. The potential negative effects are systematically passed over in silence:

- -- Marginalisation of teachers whose role could be reduced to "machine-minding";
- -- Development of negative attitudes on the part of the "best" teachers.

These observations lead to a number of conclusions:

131. Cost studies should:

i) As far as possible be standardized; Costs should be measured per contact hour and/or per teaching programme;

ii) The method should be described and the evaluation should be broken down according to the different components of the system;

iii) Try to be exhaustive and not simple evaluate hardware costs:

- -- The least understood and potentially most important costs, such as maintenance and teacher retraining, should be given priority in research studies;

-- The effects on staff costs of introducing NIT should also be examined as a matter of priority;

-- It is necessary to distinguish between the cost of producing equipment and the price paid by educational establishments;

-- Longitudinal studies of projects should be carried out.

132. Measurements of efficiency should:

i) Be carried out more often;

ii) Consider the affective impact on pupils and the effects on teachers' attitudes;

iii) Examine the extent of negative effects.

-- Priority should be given to measuring the threshold effects of gradually introducing NIT and the minimum contact time necessary to achieve full efficiency.

Cost effectiveness studies

133. It is essential that costs and efficiency should not be considered separately but rather in terms of cost-efficiency ratios and trends therein.

NOTES AND REFERENCES

1. Some of these figures differ from those provided by the OECD. The trend is nevertheless the same in the two series except in the case of Belgium for which the OECD gives 63.6 per cent in 1979 (as against UNESCO's 74.2).

2. Detailed data can be found in: J.C. Eicher, D. Hawkridge, E. McAnany, F. Mariet, F. Orivel: The Economics of New Educational Media. Vol. 3: Cost and Effectiveness Overview and Synthesis, UNESCO, 1982.

3. Ludwig Braun: "Report on Educational Technology". Journal of Educational Technology Systems. Vol. 12(2), 1983-84, p. 127.

4. Yves Le Corre: Undated mimeographed document.

5. It if is a matter of training for adults or individual distance-learning at home, it is obviously possible to reduce this cost by working in the evening or early in the morning.

6. cf. for example Ray Reddy: Technologies for Learning. Carnegie. Mellon University. Undated document.

7. cf. Jacob Schwartz: Thoughts on Computer-Aided Instruction. New York Univerisity. Undated document.

8. The detailed reasoning can be found in: La Lettre du CEFI, n° 25, op. cit. 1983.

9. Another United States' evaluation (Strategic Incorporated) goes in the same direction since it considers that the cost-efficiency ration should improve by about 20 per cent a year between 1983 and 1990 while the average price of a microcomputer will probably fall by only $2 000 to $1 000 over the same period.

10. Jacob Schwartz, op. cit., gives division by four as an order of magnitude.

11. CEFI letter n° 25, op. cit.

12. Here again, however, a lack of concordance between the evaluations can be seen, as another French source assesses maintenance at only 8 per cent of investment cost, i.e. about one quarter the depreciation over three years.

13. Idem p. 1.

14. This is the usual official figure. Some authors put forward a significantly lower figure, however.

15. More detail is to be found in some of the background documents for the OECD Conference.

16. A. Melmed: Educational Productivity, The Teacher and Technology, mimeographed document, U.S. Department of Education, Washington, Nov. 1983, p. 3 and 4.

17. Arthur Melmed, op. cit.

18. It is interesting to note that B. Schwartz (l'Informatique et l'Education, 1981) obtains comparable orders of magnitude.

19. cf. The synthesis study by J.A. Kulik and R.L. Bangert-Drowns: "Effectiveness of Technology in Precollege Mathematics and Science Teaching", Journal of Educational Technology Systems. Vol. 12(2), 1983-84, p. 137 to 157.

20. cf. M. Ragosa, P.W. Holland and D.T. Jamison: Computer Assisted Instruction and Compensatory Education: The ETS/LAUDS Study, Mimeographed report, June 1982.

21. The authors consider, however, that these findings are less reliable than those concerning mathematics.

22. A.J. Gaserud: Improving the learning process of correspondance students by use of computers. Report to the Joint Council of the European Council for Education by Correspondance (CEC) and the European Home Study Council (CHSC), Paris, April 1982.

23. S.S. Hartley: Meta-Analysis of the Effects of Individually Paced Instruction in Mathematics. Doctoral thesis, University of Colarado, 1977.

24. cf. The examples cited by J.K. Kulick and R.L. Bangert-Browns, op. cit., p. 153. The effects appear to be more marked in higher education than at secondary level.

25. cf. G. Bracey: Computer-Assisted Instruction: What the research says and does not say and can't say about its effectiveness. University of Virginia. Mimeographed document. The author notes in particular the beneficial effecs on slower or handicapped pupils who regain confidence in themselves when they can work at their own rate without being reprimanded.

26. L. Braun, op. cit., p. 126.

27. For a more in-depth discussion of the profound changes to be expected in the organisation of education and in higher education curricula, see: Samuel L. Dunn: "The Changing University: Survival in the Information Society". The Futurist, vol. XVII, n°4, August 1983, pp.55 to 61.

28. Studies cited by L. Braun, op. cit., p.126.

29. cf. Their report for the OECD Conference [CERI/NT/84.05], dealing with software and courseware for a multimedia educational environment, which gives a very detailed analysis of the conditions required for producing good courseware and the characteristics of a "good" language for pupil/machine communication.

30. It can be seen, for example, how much the ancient history lesson given as an example in paragraph 11 of the report by Y. Le Corre and J. Schwartz depends on free access to many different iconographic documents and film sequences.

Annex 1

THE PROBLEMS OF MEASURING EDUCATION COSTS AND THE NECESSARY METHODOLOGICAL CHOICES

1. Available data concern expenditure, not costs. This is usually public expenditure and even merely forward estimates set out in final budgets. International bodies could and should play a major role in the search for more reliable data.

1. Importance of the Distinction Between Cost and Expenditure

2. Economists seek to determine optimum allocation of scarce resources. The cost of an activity or good is represented by the value of the opportunities which have had to be foregone. The expenditure committed with a view to providing an activity or creating a good therefore sometimes has to be augmented by the cost of what is foregone.

3. Potentially, each pupil pursuing studies beyond compulsory schooling and each adult following a training course during normal working hours lower output by the equivalent of their work input. The same applies to any extension of compulsory schooling. Any allocation of additional resources to education therefore involves foregoing other goods or other satisfactions. The expenditure observed constitutes a yardstick (albeit imperfect) for only part of the value of the resources used and hence of the sacrifices made, i.e. of the cost of education.

4. Education forms part of public goods. In fact, however, this merely means that a large share of the direct cost is borne directly by the community. Data on the expenditure by the various groups concerned (government, local communities, business, households, etc.) provide an inaccurate picture of the breakdown of the efforts made by each party towards education inasmuch as the costs of what is foregone are shared among them in different ways.

2. Expenditure

5. The amounts spent on education come from various sources. Generally the greater share comes from public sources:

a) Public Expenditure

6. This is shared between the central or federal government and regional or local authorities.

i) Central government: alongside the ministry (or ministries) of education, other government departments also financing educational activities have to be taken into account.

ii) Local authorities: Local authority expenditure on education is often sizeable but not always easy to identify as it does not (or not always) figure under specific budget heading.

iii) External public aid: In the less-developed countries this is sometimes very high but in OECD countries it is usually non-existent or negligible.

b) Private Expenditure

7. This comes mainly from students and/or their families, but business is playing an increasing role, especially for financing further training. In some countries, a third group -- sponsors -- may play an important role in higher education and research.

8. Students and their families: Their education expenditure covers not only enrolment and tuition fees but also all the outgoings entailed in student life: educational supplies, but also transport, clothing, food, etc. It is therefore difficult to evaluate since in most cases it is a matter of identifying net balances (which may even be negative if some expenditure is highly subsidized) in households' "ordinary" expenditure. The increasing use of modern teaching aids (e.g. mini-computers) may possibly shift costs over to families if the pupils themselves acquire this type of equipment.

9. Business: This type of financing concerns not only training organised within a specific and regulated institutional framework but also further training provided at the enterprise's instigation within its own premises, sometimes in the form of on-the-job training. The latter type of expenditure is much more difficult to measure than that for institutionalised training.

10. Sponsors: In quantitative terms their contribution is small but it may prove decisive where a new programme is to be launched or an innovative investment is to be made.

3. Available Data and Their Limitations

a) Almost everywhere available data are incomplete:

11. Official data merely concern expenditure. There are few reliable studies on costs, accurate data on household expenditure are available in only very few countries and never cover long periods, even in the case of public expenditure, local authorities' expenditure is rarely properly measured. They are generally underestimated.

b) Available data are not always very reliable:

12. Data on public expenditure usually come from budget documents and concern estimated expenditure (final budgets) and not the amounts actually spent (financial accounts). Data from different sources do not always correspond (calendar year/fiscal year, account taken/not taken of all ministries involved, different evaluation of local authority expenditure, etc.).

TRENDS IN GOVERNMENT EXPENDITURE ON EDUCATION
(% of GNP spent on public education)
IN SELECTED OECD COUNTRIES (1970-81)

COUNTRY	1970	1972	1974	1976	1978	1980	1981
Australia	4.17	4.63	6.02	6.16	6.06	5.77	-
Denmark	7.08	7.60	7.94	7.57	7.49	-	-
France	-	-	-	5.82	5.81	-	-
Italy	4.46	5.09	4.62	4.97	5.11	5.60	6.40
Japan	3.57	3.96	4.66	4.85	4.98	4.97	4.96
Netherlands	7.00	7.19	7.39	7.70	7.81	-	-
Germany	4.03	4.66	5.16	5.05	4.93	5.14	-
United Kingdom	5.34	5.77	6.02	6.40	5.78	-	-
U.S.A.	5.29	5.78	5.93	6.12	5.72	-	-

Source : OECD - National accounts.

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INFORMATION SOCIETY AND GENERAL EDUCATION

1. The attached document has been prepared by Giovanni Lariccia, National Council for Research, Rome, Italy, and Jacquetta Megarry, Editor, "World Yearbook of Education", United Kingdom, in their capacity as consultants to the Secretariat. It will serve as a background report for the Plenary session on Theme 3.

2. The views expressed are those of the authors and do not commit either the Organisation or the national authorities concerned.

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INTRODUCTION

1. This report on the Information Society and General Education integrates data gathered from four sample case studies with ideas from the literature and from other countries, to achieve an overview of current trends in OECD countries. The four were written by OECD experts: namely P. Delmas for France, G. Lariccia for Italy, Tj. Plomp for the Netherlands and J. Megarry for the United Kingdom.

2. The first section of this report indicates the scale of our task. The complexity of the relationships between the Information Society and General Education has been described in an earlier report prepared for the OECD Secretariat (Lariccia, 1983). The second section summarises a selection of the country-by-country studies, grouping them into eight categories. This sets the scene for the general discussion of issues and priorities in the third section.

Chapter I

THE COMPLEXITY OF THE INFORMATION SOCIETY: A CHALLENGE FOR EDUCATION

3. New Information Technologies (NIT) are dramatically changing every facet of our society, challenging the role and functions of our educational systems. It is already commonly accepted that a new kind of literacy is required to live in a world dominated by new information processing tools and media. It is less widely understood that a new kind of knowledge, and perhaps a new type of wisdom, is essential to understand the new educational needs and long-term goals of individuals and nations in the era of NIT.

A. Problems of Growth in the Information Society

4. It is in the nature of NIT that quantitative changes breed qualitative ones. The growth of the new information technologies has been incomparably faster than that of the "old" technologies of the railways, the motor car or the aeroplane. Each of these old technologies has had profound effects on our society; NIT may instead provoke a "quantum leap" proving revolutionary -- not evolutionary -- in their impact.

5. The growth rate in NIT is illustrated by the decrease in the costs of computers. There is a consensus among NIT experts that approximately every two years the computing power available at a given purchase price will double. This pace is likely to be maintained for at least the next 25 years; it is already guaranteed by today's advanced technological research. One expert (Reddy, 1983) considers the use of computers in education against a frame of reference in which by 1990 a $100 computer has the power of today's "supercomputer" Cray-1:

> "I anticipate that we will have an affordable Cray within the next decade: a 100 MIPS (million instructions per second) processor; a million characters of random access memory; and a four million characters of program (read only) memory."

The social consequence of this tremendous acceleration is that most applications that are too expensive today will be affordable tomorrow.

6. What are the social costs and implications of this explosion of

possibilities? Are we prepared to support it with adequate educational policies to improve or maintain our social and civil structures? How can we guarantee to our citizens their civil rights and equality of access to educational and employment opportunities in the NIT society of the future?

7. Access to NIT is constantly becoming easier as computer languages and systems are increasingly designed for first-time users. The result is that, at least in principle, everyone could use computers for storing and retrieving personal information, for writing and editing, and for solving problems in any kind of professional activity. Computers may soon replace pencil and paper both for individuals and large organisations. But what demands does this place on an individual's skills and attitudes? What kind of basic education is required today to allow individuals to make the most of NIT tomorrow?

B. NIT and Human Learning

8. Scientists are starting to investigate how NIT can extend the individual's capacity to think and even to feel. These new capacities are as significant as the advent of printing technologies. Notions of time, space and information are in fact rapidly changing in our culture due to the influence of NIT. Our models of thinking, intelligence, memory, attention, and hence the derived notions of knowledge, learning and teaching are also going to change their meaning:

> "It is known that with rapid changes in technology most of the tools and techniques we learn in school (and college) will be obsolete well before we are ready to retire. Much of what is not obsolete will be either irrelevant or cumbersome for solving problems that arise in day-to-day working life. The only useful part of the education will have been the acquired ability of 'learning-to-learn'." (Reddy, 1983)

9. New models of learning and intelligence are not only derived from the advent of expert systems and knowledge-based systems. Notions of intelligence had already begun to change under the impact of communications technology and computer science. New scientific disciplines like artificial intelligence and robotics provide effective laboratories for the study of the human mind, memory and language. Scientists of a new breed -- half psychologist, half computer scientist -- are casting light on phenomena hardly attacked until 20 years ago. Some of the applications of "cognitive systems" may soon be incorporated in solid state memories, and may produce a dramatic change in the way individuals acquire basic reading, writing and communication skills.

C. NIT and New Ways of Learning

10. Some hint of the potential of NIT for changing the way we learn can be discerned from the examples below, partly borrowed from (Uhlig, 1983). It should be stressed that these are software packages which are already widely available at a very low price on most microcomputers. By comparison with the software of the near future, they are crude and unsophisticated. But already

they show great advances over the pedagogy of the past. Their significance lies in the direction they point towards.

Keyboard Familiarity

11. For many novices, mastering the keyboard presents the first obstacle to computer literacy. Yet the computer can itself be used to teach touch typing far more effectively than a human teacher or typewriter. There are already many software packages which embody elements of "an instructional theorist's dream". Effective instruction is crucial with a highly motivating format including self-pacing, immediate knowledge of results and diagnostic procedures for speed and accuracy.

Word Processing

12. Word processing (WP) software allows the personal computer user to enter words freely without concern for typing errors, to edit (correct and rearrange) those words until satisfied and to store and print perfect copies at will. WP thus transforms the teaching of writing by encouraging students to practise the professional writer's habits of drafting and revising. Since amateur WP users can produce finished work to professional typists' standards, the system also encourages perfectionism in presentation. By separating the stages of entering, editing, formatting and printing, WP emancipates the student's thoughts and words from the labour of production. WP software available on larger microcomputers sometimes includes spelling checkers, grammatical analysers, on-line dictionaries and even an electronic thesaurus. These more sophisticated products have wider implications still for student (and professional) writers.

Foreign Language Learning

13. Language learning is the third example. There are already several pocket translators for learning foreign vocabularies. But there are some features of the new word processors which may soon completely change language learning. Decreasing costs of computer memories has already made it possible to incorporate large dictionaries in personal computers. Within a couple of years, individuals could be learning a foreign language through interactive text editors and translators which incorporate and update models of the users' memory.

14. However, personal computing is by no means the only example of information technology which will affect learning and teaching in the near future. New social relations and patterns of interpersonal communication are being developed by data communication networks. Closed groups, microcomputer clubs and teleconferencing facilities (reviewed in the next section), are already building the foundation for electronic learning communities.

15. The rapid and radical changes just described are not without risk. Firstly, they are not equally accessible to all. Secondly, they are introducing into society a tremendous increase in complexity which may not only exacerbate inequality but may also threaten current educational systems and institutions.

D. Data, Information, Knowledge and Wisdom

16. In one hall of the Capitol's Children's Museum of Washington (described in the next section), there is a passage by Mark Aspen, extending a quotation from T.S. Eliot:

> "Where is the wisdom we have lost in knowledge?"
>
> "Where is the knowledge we have lost in information?"
>
> "Where is the information we have lost in data?"

Many problems of the Information Society stem from a failure to distinguish between different kinds of knowledge: there is a hierarchy extending from data through information, to knowledge and to a level above knowledge, which may be called "wisdom".

17. It is obvious that most of the NIT employment opportunities are related to the ever-growing relevance of knowledge of NIT to every kind of work. It is less obvious that data bases and their dissemination contribute to the "knowledge potential" of a nation. It is also clear that the number and quality of expert systems will affect a nation's economic power in the future. It is less easy to identify what the expert systems will fail to provide and what inequalities they will create in educational systems.

18. Knowledge is replacing energy as a basic human resource in almost every kind of economic activity. Capturing and retrieving information depends more and more on data processing and telecommunications technologies. Mastery of these technologies is vital in order to grasp the new opportunities.

E. Risks and Opportunities

19. NIT are transforming learning opportunities. Learning is no longer confined to schools, and it depends less and less on face-to-face teaching. Self-study packages, universities without walls, distance learning through viewdata, teletext and interactive video and self-help through electronic networks are all becoming accessible to more and more individual citizens throughout the world. Distance education is becoming big business for many publishers and manufacturers. The mass media (broadcast and cable television, radio, newspapers, magazines) constantly offer means of self-study and contacts for practical experience. Holiday and leisure organisations are including computer education as an option, and full-time computer camps are available for those who want to combine computer programming with a seaside vacation.

20. New risks accompany the opportunities. Chapter III of this report examines some of the long-term problems posed for governments. Here it is sufficient to cite three of the more specific and immediate risks. First, expertise in NIT demands constant updating and retraining. A Rumpelstiltskin computer expert who fell asleep in the 1960s would be fit only to be a museum curator: he would not recognise the NIT scene if he awoke in the 1980s. But

the hardware of the 1980s is no less rapidly obsolescent and software is still seldom transferable to new generations of equipment. Every five or ten years, an employee may need a completely fresh set of skills to do what is notionally the same job. This requires a continuing investment of resources and energy, both by the employee and employer. It is a process maintained voluntarily by computer hobbyists who meet regularly and engage in mutual informal education. The question is who will pay for this process for people who do not wish to commit their leisure time in this way.

21. The second type of risk could be labelled "the blind technologial imperative". Computer output tends to have an authority more spurious than that of the printed word. Yet computer systems are fallible and sometimes slow. That a task can be performed by computer does not necessarily mean that it should. In some jobs, the human touch may be vital, in others the portability and simplicity of paper or cardboard may be crucial, in others again the nature of the work may be so variable that computerisation is inappropriate. But in the last ten years, many organisations have hastily introduced computers in a mistaken belief that this automaticallly represents an "advance".

22. The third type of risk is related to the conflicts between expectation and reality. Historical accident and market forces have produced a plethora of incompatible products, systems and interfaces. The result is that using and linking systems from different sources often gives rise to complex technical problems, sometimes insoluble without disproportionate expense. This creates a crisis of credibility among "naive" users who expect all problems to be solved at the touch of a button. The discrepancy between advertisers' claims and actual performance is a persistent problem in the personal computer market where first-time buyers often part with their money little knowing what to expect or insist upon.

23. People require counselling and education to evaluate educational products and opportunities just as they need help to evaluate software packages and claims made for hardware. We are all consumers of education, and we need consumer education to guide us towards wise choices. Indeed, the ability to evaluate, select, understand products, goals, means and opportunities is exactly the kind of "wisdom" we need in the Information Society to live with the new information technologies. Spreading wisdom is the key objective in the field of General Education.

F. School Education, Vocational Education, General Education

24. Education should be the "place" where the demand for learning and the provision of effective means are matched. Education must give everybody the chance to explore and master the new opportunities of NIT while also giving balanced consideration to the risks. Different delivery systems are required by the challenge of the information society, establishing specific roles with respect to NIT.

25. The role of school education might be to prepare future citizens to enter the new society. In the domain of information technology, the school's primary role should be to promote good learning habits and thinking strategies

and to build up the fundamental concepts of NIT. Knowledge of the new technology and how to work with it should be secondary to the development of conceptual tools for thinking and learning about it.

26. The role of vocational education should remain more short-term. Clearly-identified groups of individuals need preparation for specific types of job. This entails mastery of the specific competencies and skills required for that job. Although vocational education will largely be concerned with training and retraining of actual and prospective employees, it is essential that skilled performance is based on grasp of fundamental principles. It is also vital that the training and retraining should make the fullest use of the potential of NIT for open learning. Delivery systems might include electronic media, on-the-job training, home-based self-study, tutorial support, peer group self-help and laboratory/workshop "hands-on" experience -- or any combination of these -- in a package which can be tailored to suit individual circumstances. Flexible delivery systems are the enemy of disadvantage. Multi-media provision -- especially interactive video -- offers an exciting alternative for those whose development has been arrested by low levels of print literacy.

27. The role of general education is wider still. It is to provide continuing and lifelong educational chances to everybody who needs them, when and where the need arises, irrespective of age, sex, socio-economic class, geographical location and previous qualifications. It is also to provide a support for surviving the risks of an ever-changing environment. The aim of general education should therefore give everyone open access to understanding.

Chapter II

EIGHT GROUPS OF SAMPLE CASES

28. Some of the cases summarised in this section are derived from the case studies provided by the country experts, others from the literature and from our personal experience. They have been selected on the basis of being capable of abstraction, generalisation or transfer to a different country or system.

29. The examples which follow have been arranged in eight groups along a dimension which combines structure and permanence. The first group of cases include one-off and small-scale events, while the last group consists of permanent and highly structured bodies. Inevitably, the selection is a subjective one, reflecting the interests and values of the authors.

30. In reading the cases, the distinction between the personal domain and the social domain should be borne in mind. Some cases are concerned with helping individuals to come to terms with NIT, others with the needs of organised groups, social and political organisations, businesses and institutions. Keeping abreast of NIT is becoming increasingly important to corporate bodies, which are aware of the threat posed by NIT and seek survival through adaptation.

31. Corporate bodies should profit from the recent history of innovations in this endeavour. Even in state-run enterprises and highly centralised bureaucracies, innovations cannot usually be imposed from the top downwards; attempts to do so are often counterproductive. There must be some incentive for employees to make the innovation work -- and this may require an appeal to their hearts as well as their heads.

A. Computer Camps, Plays, Festival, and Fairs

32. Even for people without previous experience of them, computers have become an attractive and controversial focus for popular events and mass meetings. People seem to seize every opportunity to get "hands-on" experiences. This is for many a preliminary to using, programming or even buying a computer; for others it is a precursor to better understanding of the role of computers in society or at work.

33. The cases below illustrate some different ways of organising these gatherings, with somewhat different objectives. All are aimed at basic familiarisation and are of short duration.

The Club Méditerranée Computer Centres in France

34. The first Club Méditerranée computer centre opened in the summer of 1981 in Kamarina, a Sicilian holiday "village". Since then computer centres have become a major activity in over 42 clubs in various parts of the world, involving over 100 000 people in the first three years.

35. The Kamarina centre offers games, information services, self-study courses and applications software so that participants can familiarise themselves, play, and learn with and about the whole spectrum of NITs. In the first four months of operation 2 500 out of 12 000 participants completed a full self-study course and 1 500 created BASIC programs.

36. The high costs of Kamarina holidays was reflected in the social status of holiday makers -- professional, managerial and business occupations predominated. In July/August only one-quarter of participants were female, with a slightly higher ratio in other months. The composition of the participants is thus determined by market forces and self-selection in response to a commercial initiative. The revelation by the Club Mediterranee of such a large demand has inevitably attracted a flood of manufacturers offering to supply equipment. In effect, these camps offer a huge shop-window to holidaymakers with considerable purchasing power -- both as individuals and through their employment.

37. Before contrasting them with a less commercially motivated movement in the UK, it is instructive to compare some diverse and smaller-scale activities in Italy. These are typical of a less structured approach to general education in NIT.

A Week on New Information Technologies in Foligno (Italy)

38. Umbria is one of the 20 Italian regions with a long-standing tradition in festivals set in beautiful middle-age and renaissance scenarios. In 1982, Foligno hosted a special Week on Informatics which attracted people and resources from all over Italy.

39. The Week was efficiently organised by the "Centro Regionale Umbro Elaborazione Dati" (CRUED), the Umbrian Technical Agency for Data Processing. Several public debates were held on the importance of computer culture in our civilisation, and CRUED demonstrated all the computerised services offered by the regional administration.

40. Special emphasis was given to the educational projects in which Regione Umbria is investing heavily in the next few years; notably the project IDEA to introduce computers in the nursery and primary schools. This will provide the first major field test of the Italian version of LOGO published by Mondadori.

A Computer Play in Milan

41. In December 1983, the first Computer Play, a new kind of conference, was held in Milan. It included the usual public debate on the importance of video and computer games in general education. It also featured a large exhibition of hardware and software on the subject of "games and education". Unlike an ordinary commercial exhibition, many of these exhibits were set up by schools, universities and computer clubs. The Play also included a contest for the best computer game, which produced educational software of very high quality. Around 3 000 people, mostly between 13 and 18, attended.

An Educational Computing Fair in Rome

42. The Educational Computing Fair (ECF) held in Rome in January 1984 was in someways similar to the Milan "Computer Play". It was sponsored by the Department of Education of the District of Rome, and concluded a two-year project in computer literacy which has engaged almost 25 per cent of the senior high school population.

43. ECF had three main components. First, there was a set of five conferences on general problems in New Information Technology and Education. Second, were five "Conferenze Dolci" (literally "soft conferences"). These were offered by young and talented people and included electronic story telling, electronic music, electronic painting, language and science learning and teaching, all illustrated by the live use of computers. Third, there was a set of "poster sessions", at which every participant could demonstrate his/her software on a set of computers provided by the organisation.

Instant Literacy Courses within Commercial Exhibitions

44. Exhibitions and fairs related to computer and information technology products are becoming commonplace in every country. These exhibitions usually have little educational value. Though many of the visitors are novices and want to understand the potential value of NIT in their private and working lives, there is seldom any means of matching their needs with what is on show. All too often, such visitors leave baffled and confused.

45. In an effort to overcome this problem during some of the major Italian fairs, the Italian magazine MC Microcomputer has organised several free two-hour introductory sessions. Roughly one per cent of the visitors attended the courses; the limit was imposed by lack of space and teachers, not by lack of demand.

46. Each participant in the class of 30 had a machine on his or her desk and was able to continue playing around with it after the lesson. A helpful booklet, prepared by the magazine editorial board, accompanied the presentation. Afterwards, some participants expressed their appreciation of the event in letters to the magazine.

47. Considering that such exhibitions attract hundreds of thousands of visitors every year, this example suggests an important method for increasing their general educational value.

INTER-ACTION Community Computer Camps in the United Kingdom

48. The INTER-ACTION Trust Limited is a registered company and charity involved in a great variety of techniques for community self-help. Its strategy is to inject resources and ideas, to provide support during development, and -- once a nationwide network of autonomous local groups is established -- to encourage them to form a federation to sustain the work. The first series of Community Computer Camps was established in London during 1982. Six one-week non-residential camps for eleven to sixteen year olds were offered during the summer holidays. Of these first 224 students, 42 per cent were from inner-city London, and 23 per cent were girls. Two-thirds of the students had no previous experience of programming, but most completed successful projects before they left and 64 per cent wanted to join a computer club to develop their interest.

49. Crucial to the success of the INTER-ACTION Camps is their high ratios of tutors and of computers to students. The fact that these can be combined with low fees (from £20 per week down to £5 per week) is a measure of the organisation's success in attracting subsidy, sponsorship and donations in kind. They also have a flexible approach to recruiting computer studies students as tutors, to using existing spaces made available by local authorities, and to rewarding generous computer manufacturers by publicising their contribution widely.

50. INTER-ACTION aims to establish a nationwide network of 500 camps by 1985 using the same basic model. It has demonstrated its ability to change the usual pattern of under-participation by females, by students of mixed race and by those from inner-city areas by marketing the camps specifically towards these target groups using specialised networks of contacts. The motivation behind Community Computer Camps is three-fold: avoiding waste, redressing under-privilege and building community self-help. The approach is well documented in a practical handbook for those wishing to establish Community Computer Camps.

51. To close this group of cases, here is an ambitious French project mounted with government sponsorship. It is one of many French projects initiated by the Centre Mondial Informatique et Resources Humaine (CMI) whose activities are covered in the eighth group of cases.

"Holidays for the Future" in France

52. In summer 1983, together with several public agencies, CMI launched a major project called "Holidays for the Future" with the personal backing of the Prime Minister. This was the first stage of a large-scale action programme called X2000 which aims to set up 1 000 regional permanent resource centres for NIT. The initial grant was for FF 10 million, supplemented locally by the regional authorities. Almost 400 centres with more than 2 000 Thomson T07 microcomputers all over France were open on average for two months, to generate interest in the new information technologies and to give a wide variety of people the opportunity to handle a computer. Admission was free and enrolment was not generally necessary. Methods of organisation were left open to each centre.

53. The centres were visited by almost 200 000 people, about 40 per cent

from 12 to 18 years old. Interestingly, the project was more successful in the most disadvantaged areas.

54. The computers loaned to the centres were to remain there for the year to be available for social and occupational integration activities by the Ministries of Vocational Training, Leisure and Youth Sports. The municipal authorities also plan to continue the venture by setting up initiation centres for their residents.

55. A noteworthy feature of this project is its multiple use of the same structure and facilities for different purposes, including local government educational projects. It also illustrates collaboration between the public sector and private enterprise, and forms an interesting contrast with the ITeCs covered in the third group of cases.

56. Ultimately the main goal achieved by such a large-scale project is the general raising of awareness. Providing the whole population with easy access to such facilities is a major step toward equalising opportunities.

B. Permanent Centres and Exhibitions

57. Science and technology museums offer a more permanent opportunity for visitors to learn about and participate in information technology.

The Capitol's Children's Museum of Washington

58. This is a clearcut example of action research in general education. The section devoted to computers and communications is incredibly rich in good examples; the new technology is presented in a way that emphasizes continuity with other eras and civilisations.

59. The museum is a private institution, supported by many corporations and institutions. It publishes a good magazine and has a research group in computing which has produced important educational packages.

60. Equipment donated by the Atari corporation enables instant practical courses to be run for visitors who may book in advance from anywhere in the United States.

61. The museum has been designed with a view to the long-term future. Local networks (for data, voice and images) are gradually becoming operational. A satellite station allows broadcasting and reception of other types of information. A powerful computer assists with the booking of groups of visitors and will allow the printing of "instant books" for them to take away after their visit.

The Evoluon of Amsterdam

62. Evoluon is a permanent exhibition of 4 700 square metres which explains technological objects familiar to all of us and tries to convey the role of

science in the ever-changing world. Founded by N. V. Philips in 1966, and financed by the Dutch Philips Company, it is visited every year by 450 000 people and has special facilities for schools. Its scope includes the meaning of technology for society, the importance of life and health, the problems of comfort in and around the house, and issues related to recreation, education, communication and technology for industry. Special presentations focus on computer technology history and applications. The central question which the Evoluon tries to answer for each visitor is "what does technology do for me?"

C. Between the School System and the Job Market

63. Several countries have taken initiatives to prepare the labour market for the advent of NIT. The need for computer awareness for the masses is urgent and demands the services of very large numbers of teachers and tutors. This massive short-term demand creates severe organisational and logistic problems, as once the initial need is met, quite different sorts of manpower and resources may be required. The advent of NIT has created a training need amounting to an emergency; one French project has tackled it with a crash programme in the spirit of national service.

The "Soldiers of Informatics"

64. This project was mounted by the Centre Mondiale Informatique in connection with the "Conference des grandes écoles". Forty young people serving in the French army, with recent degrees in informatics from the most prestigious "grands écoles" have been allowed to spend their national service training unemployed people in NIT. The training was done rigorously, under the direction of a team of specialised teachers, and the soldiers were given extra pay.

65. The thinking behind this initiative is an assumption that the challenge of preparing the rising generation for NIT is comparable to that of the nation's defence. It is a short step to contemplating something like a "draft" if only to meet the most basic educational needs of the nation with respect to NIT.

66. Something of the same urgency can be seen in the rapid establishment of a network of Information Technology Centres (ITeCs) in the UK. These are intended to be a permanent contribution to education and training in NIT.

Information Technology Centres (ITeCs) in the United Kingdom

67. The ITeC initiative was announced in 1981 and a network of 175 centres is expected to be complete by the end of 1984. Interestingly, none of the UK departments of education were involved in their establishment: they represent a joint initiative between the Department of Industry [now the Department of Trade and Industry (DTI)] and the Manpower Services Commission (MSC). The objective of each ITeC is two-fold:

i) To help unemployed young people (especially under 18) to get vocational experience and training in NIT so as to help them find jobs; and

ii) To establish co-operation with local businesses by developing and producing marketable products and services using NIT.

Although ITeCs vary in their nature, the normal pattern is for sponsoring bodies (local authorities, technology companies and others) to form a special company with liability limited by guarantee.

68. ITeCs normally have 30-40 trainees, attending for between six and twelve months at a time. Trainees are encouraged to seek jobs or full-time education opportunities, and may leave the ITeC course for these reasons. Curriculum guidelines suggest four main activities: electronics, computing, the electronic office and some production activity. Induction training allows trainees to sample these areas before deciding where to specialise. Some assistance is given in developing life and social skills, and there is personal guidance and counselling. On departure, each trainee receives a Leaver's Certificate detailing their work experience, training and further education.

69. The ethos and atmosphere of an ITeC resembles a place of work rather than an educational institution. Although demand often exceeds the supply of places, selection is unlikely to depend on academic qualification and school reports. Some ITeCs use their full-time trainees as tutors for computer literacy courses mounted for participants in the Youth Training Scheme (YTS). Such participation is revenue-earning, since the MSC pays the ITeC to host these courses. It is also a good educational and social challenge for the full-time trainees to have to pass on their newly-acquired skills and competence to the YTS trainees. In effect, the ITeC supervisors operate at one remove, monitoring the quality of the training provided by the full-time ITeC trainees.

70. It is uncommon for the ITeC supervisory staff to have had any previous experience of teaching, let alone to possess a teaching qualification from a college of education or university. This underlines the extent to which the whole ITeC movement has by-passed the normal channels and practices of British education. Despite official ambivalence on the subject, many ITeCs have opened up their facilities to the community, computer clubs and general education: by October 1983 55 per cent had some kind of open access arrangements.

D. A Few Paradigms of Social Integration

71. An important but little-known application of computers is as a means of helping individuals with problems of adjustment to become better integrated into society. This may become a major arena for action research in the next decade. The programming language LOGO is of especial importance in this context. Although LOGO is much more than a tool for special education, its unusual combination of power and friendliness makes it uniquely suitable.

An Introduction to LOGO

72. LOGO is a powerful programming language devised by Seymour Papert of MIT in Boston, Massachusetts (United States). His background combines advanced research on Artificial Intelligence and some philosophical reflection on developmental psychology much in the tradition of Piaget.

73. LOGO embodies a simple syntax (close to that of natural language) with a set of friendly and easy-to-learn "primitive" commands. These give the learner immediate control of some special devices which "inhabit" the world of LOGO. The most famous is known as a Turtle -- a floor robot with a pen for leaving a trail of its movements. LOGO commands allow children to plan an entire course of action for the turtle "as if" they were guiding a blind friend to reach an object in a room. Turtles may also be represented graphically by shapes on the computer screen (screen turtles) controlled in the same way.

74. LOGO's power as a tool for "learning-to-learn" is illustrated by a handful of "powerful ideas" built into the approach. "Guiding the turtle" is one such metaphor, and "teaching the computer" is another. The concept of programming is made as easy to understand as "giving directions" to a friend.

75. In the late 1970s, after some ten years of thorough experimentation with children of different age and socio-economic status, LOGO was made available on several popular microcomputers.

76. The arrival of LOGO on the TI 99/4, APPLE II, ATARI, COMMODORE 64, Sinclair Spectrum and BBC Micro has helped rapid diffusion of this language. Generally each LOGO implementation has been translated into each country's native language so as to provide young learners with a natural learning environment.

77. LOGO is not only a programming language, but also a very stimulating environment in which mistakes are not punished but valued as a necessary step towards learning. Thus "debugging" a programme is a metaphor for the general process by which children's internal models gradually come to correspond with the outside world.

Use of LOGO in a Special Integration Course (Abbaye Association)

78. The Abbaye Association is a non-profit-making association involved in training potential drop-outs and helping to prevent delinquency.

79. In 1982-83 it decided to include computer training to promote social integration, to encourage success and to provide some technical training. It felt that computers help to individualise teaching, that they provide a valuable new communication medium and that they are a natural vehicle for technical training.

80. The power of computers to promote learning-to-learn was expected to combat the recurring failure pattern typical of many educational drop-outs. And by using "soft" technology, they hoped to reduce the alientation induced by technology in the society at large.

81. The project was planned in April 1982 through a set of meetings with Seymour Papert during his stay at CMI. The Abbaye got five APPLEs with LOGO from CMI and started its course with 22 trainees of whom three dropped out after a month. Introducing LOGO required a reorganisation of the timetable and curriculum so that it was integrated into the teaching of all subjects, especially in language work. A "self-service" arrangement gave trainees freedom of choice in pursuing their interests. An evaluation showed wide variation in the mastery achieved: four trainees learned none of the formal aspects of the language, whereas four others learned how to use procedures, edit routines and variables. The project showed that the adaptation was easier for the more isolated individuals than for those more strongly tied to a social group. Abbaye intends to continue with the scheme although it was handicapped by a lack of flexibility in the Ministry of Education's examination arrangements.

Individuals with Learning Disabilities

82. In Italy a national version of LOGO has been prepared on the TI 99/4A computer. This version has allowed experimental treatment of psychological problems with individuals and families by psychologists and family therapists. In one case, a 17-year-old youngster with severe learning disabilities spent a lot of time learning LOGO and prepared his own manual for it in a period of only three months. One striking feature was that his LOGO sessions lasted ten times longer than his habitual span of attention.

The Use of LOGO for Treating Down's Syndrome

83. LOGO has also been appreciated by parents of severely handicapped children. A project for stimulating very young children with Down's syndrome has been initiated by John Heinemann and Maura Cova for the Association of Parents of Down's Children in Italy.

E. The Telematic Connection

84. The opportunities offered by NIT for general education extend far beyond stand-alone microcomputers. Telematics is a general term for information processing and transfer across a distance including viewdata and teletext. Although the application of telematics to general education is still in an experimental stage, the country case studies include a variety of examples with contrasting features.

The Velizy Experiment

85. In this experiment 2 500 families in the Paris area were provided with Minitel terminals giving them free access to videotex services. Videotex is a general term covering passive or one-way communication (teletext) and interactive services (viewdata). Passive services provided news, travel and other information services, whereas the interactive services allowed the user to send messages, order goods, book tickets and participate in computer

assisted learning. The Direction General des Telecommunications (DGT) sponsored research into the personal characteristics of different levels of user. At the outset, all users were given two educational programs and both an electronic and a printed index to the information available.

86. "Heavy users" formed 30 per cent of the total, learned to operate the terminal inside a fortnight, and used a variety of services including the interactive facilities; some called the system every day. By contrast, 25 per cent of the total group never used the terminal at all and wanted to return it. The remaining 45 per cent of "very infrequent" to "medium frequency" users made little use of the interactive facilities and used the system only once or twice a month.

87. Age and sex were strongly linked to participation. Pensioners were usually very infrequent users and youngsters were heavy consumers of games irrespective of their socio-economic status. Females were generally under-represented, but among heavy users they came nearer to equal participation. Socio-economic status was also an important variable, with professionals and white-collar workers dominating the higher use categories, and blue-collar workers frequent among non-users and very infrequent users. One of the main obstacles was the difficulty users perceived in operating the terminal, but another was the lack of relevance of the information that DGT provided. Thus some of the non-users were from business and professional occupations who wanted more specialised information services. Interestingly, some non-users did not return the equipment: the mere possession of the equipment seemed to confer social status.

Microtel -- Ademir

88. The Microtel Club was set up in 1978 as a non-profit association with support from the Post, Telephone and Telegraph (PTT) administration, from the Centre National d'Etude des Telecommunications (CNET), from the Agence de l'Informatique (ADI) and from various public and private agencies.

89. With some 14 000 members and 120 regional clubs, the "Federal National Microtel des Associations et Clubs de Micro-Informatique et Telematique" is now the largest grouping of microcomputer clubs in France. For a moderate annual subscription, a Microtel member receives not only microcomputer software and magazines, but also a large range of special services and opportunities, including the option of borrowing a microcomputer.

90. Local Microtel clubs encourage "understanding" of the potential of computers for individual needs and promote the informal exchange of know-how at any level of competence. Beginners find the clubs valuable for getting rapid and reliable information. Many professionals seem to have been able to find software relevant for their jobs. And the enthusiasts, including some computer specialists, find the exchange of experience rewarding.

91. The Ademir Association is aimed at youngsters under 15, their parents and teachers. At least six teachers are needed to set up a local section, which meets in a local school or college. With 3 500 members and 80 local sections, Ademir has proved effective in promoting computer literacy and the creation and use of educational software. Ademir publishes a newsletter (36,000 Micros) and also offers teachers special courses in computer

applications in education at a fee of FF 1 500 for five days.

92. The experience of Microtel Ademir suggests that computer know-how may diffuse more readily in the "protected" environment of clubs and association. Some kind of "social reward" provides an incentive for people to share their expertise. Information technology is as dependent on its social mileu as are activities like chess and hunting. Access to such informal channels of learning is strongly socially determined, so informal agencies are unlikely to reach large proportions of the population. Because of their flexibility and freedom from government regulation, however, they find it much easier to keep up-to-date than formal channels of state education.

Computer Based Teleconference

93. Computer Based Teleconferencing is very popular in some areas, especially in the United States. This is a sophisticated system for exchanging personal messages held on a large computer. Messages can be directed from every participant to one, some or all of the participants and may be public or private. A conference chairman directs the review and indexing of incoming public messages and acts like the chairman of a face-to-face conference.

94. Teleconferencing is an example of a new social linkage made possible by electronics. Although such facilities tend to seem more costly than telephone and postal services, they are heavily used by their enthusiasts and for some purposes can be both cheap and efficient compared with business travel and conventional conferences. Remembering that a high proportion of telephone calls dialled are unsuccessful in making contact, especially where long-distance connections and different time zones are involved, electronic mail can actually be highly economical. The fact that users can control when they accept messages (rather than being constantly at the mercy of interruptions) is a valuable benefit.

Prestel: The British Lead in Viewdata

95. Prestel was launched by British Telecom in 1978 and was then the world's first public viewdata (interactive videotex) service. Although the potential of such a system was seen to be immense from the beginning, its actual uptake by paying customers has been disappointingly slow, especially among domestic consumers. Compared with the rapid spread of Teletext televisions in British homes, the theoretically more powerful two-way system has been surprisingly slow to catch on. Part of the explanation lies in the costs: once you have bought a Teletext television (about £100 additional cost) the running costs of Teletext are effectively zero, so there is every incentive to make use of the information services. Prestel's running costs, on the other hand, are considerable: you pay for telephone connection time, for computer time and also for individual frames. The total varies according to the time of day, and the distance from the Prestel computers and the decisions made by Information Providers: excluding frame charges, a subscriber might pay anywhere from £0.66 per hour to £15.90 per hour.

96. Over 230 000 pages of information were available by 1983, provided by over 1 000 Information Providers. Around 50 per cent of Prestel business was

accounted for by the top ten Information Providers, who include major sources like British Rail with over 13 000 pages. This perhaps reflects the predominance of business users (notably travel agents and tour operators). Although Prestel's initial policy was to provide a general information service, and to act as a "common carrier", there has been a marked trend towards provision of specialised and private information services. Notably among the recent growth areas have been Closed User Groups (CUG) and Gateway. CUG provide Prestel users with a confidential information network within Prestel, including electronic mail between different locations and a hierarchy of access arrangements for different categories of users within the Group. Gateway is a facility whereby the Prestel user can make direct contact with an external computer, for example allowing a salesman to interrogate the mainframe at his company's headquarters, or a traveller to access realtime information from an airport departures board. The growth of services like these and the importance of the direct marketing potential underlines the extent to which Prestel has been responding to the needs of business.

97. Clearly the Prestel data base contains an immense amount of information and represents a major educational resource both in itself and for the lesson it illustrates in information handling. It has a potential role in the teaching of information technology, social studies, business studies and economics and a major Council for Educational Technology project has investigated its scope both as an educational resource and as a mechanism for delivering telesoftware. (However, one CET project teacher noted that his school had surprisingly little use for up-to-the-minute information.) CET found great enthusiasm for local viewdata software systems, which proved both valuable and cost-effective, not only for teaching about Prestel, but also as a project in collaborative knowledge building for teachers and pupils, with applications ranging from electronic magazines to the design of crisis simulations.

Micronet 800

98. Micronet is potentially the most successful example of a CUG within Prestel. It attracted more than 5 000 subscribers in its first seven months of operation. By contrast, Prestel attracted only 26 268 users in its first five years. The Micronet annual subscription of £52 gives full access to Prestel and an additional 20 000 Micronet pages which include free software ready for downloading into commonly available microcomputers.

99. About 100 free programs for the most popular makes of micros were promised for the first year of operation, and this collection was to be changed on a regular basis. In practice these promises proved over-optimistic. It is unquestionably the lure of free software that has tempted many subscribers into the Micronet club. Opinions differ about the quality of the free software, but Micronet undoubtedly represents a cheap means of accessing Prestel services for microcomputer owners.

100. Furthermore, Micronet subscribers can download commercial packages at a worthwhile discount compared with shop/mail order prices. The telesoftware mechanism is also faster and more reliable than conventional shopping for a disk or cassette which may prove faulty.

101. Insofar as Micronet encourages its subscribers to contact each other

and to influence its management by sending electronic messages, it may develop greater significance for general education. If enough subscribers join forces within Micronet, they could establish an influential electronic community with strong mutual communications capable of bringing real pressure to bear upon publishers, broadcasters, manufacturers and Information Providers. However, Micronet is a commercial enterprise at present confined to a sub-set of a privileged population of British microcomputer owners. Its growth, although rapid, is too recent to project reliably, and its overall strategy not yet clear.

F. General Education within the School System

102. This theme is almost outside the scope of our report as it is covered by other OECD reports. But developments within the school system affect the latent resources available to general education, and conversely, the rapid changes in the world outside school have caused some governments to mount major programmes to help the school system to adapt. Two important examples exist in the United Kingdom: the Microelectronics Education Programme (MEP) and the Micros in Schools Project at the Open University.

The Microelectronics Education Programme (MEP)

103. MEP is a government-funded programme which aims "to help schools prepare children for life in a society in which devices and systems based on microelectronics are commonplace and pervasive." It was announced in March 1980 with a budget of £8 million to spend over 1981-84 and a remit to cover schools in England, Wales and Northern Ireland; Scotland is covered by a separate programme. The extension of MEP funding to £20 million was announced during 1983.

104. Decentralising control has always been an aim of Director Richard Fothergill's strategy. From the very start, MEP's whole approach has been to work through Regional Information Centres (RICs) in partnership with groupings of local education authorities. Inevitably, the 14 RICs vary in the strengths and weaknesses of their staff, the accessibility and opening hours of their premises, the emphasis they give to different aspects of MEP's aims and their effectiveness in disseminating information about their activities. MEP thus seems to take on a subtly different identity in different parts of the country depending on the RIC in question.

105. In order to maximise the impact of funding which, although major, has to be applied to a school population approaching 10 million, MEP has pursued a policy of working through other agencies: commercial software publishers, companies like British Petroleum (BP), International Business Machines (IBM), Standard Telephones and Cables (STC) and public organisations like the British Broadcasting Corporation and the Open University (see below). The success of this policy is illustrated both by the quantity of resources it has sponsored -- print, audiovisual, software, firmware and hardware -- and by their quality. The policy also means that many other agencies have a vested interest in the development and marketing of these resources. This guarantees their future and makes them independent of the vagaries of central government funding.

106. MEP was planned for a Britain in which microcoputers were just beginning to spread in secondary schools and were virtually unknown in primary schools. During 1981-84 various 50 per cent subsidy schemes were offered by the Department of Industry (now the Department of Economics and Industry) to stimulate the purchase of British micros and peripherals. These rapidly transformed the picture so that by 1984, every British primary school had at least one microcomputer and secondary schools had an average of four. This enormously increased the pressure on MEP resources and led to the setting-up of an MEP National Primary Project in 1983. Furthermore, although MEP's remit did not include post-school education, demand has been such that the DES Further Education Unit circulated an annotated directory of suitable MEP material in 1984.

107. In addition, MEP has undoubtedly influenced what is available on the domestic market: pressures on educationally aspirant parents are cleverly exploited by advertisers. Sinclair has successfully marketed its Spectrum together with "the same software that the government approves for use in schools", and the Acorn Electron has been advertised for its ability to run MEP software. Again, various battery-operated devices sold as toys on the domestic market have acquired educational respectability as a direct result of MEP-funded curriculum development projects and associated books: for example Bit Trak, a Milton Bradley programmable robot vehicle, and the Texas Instruments hand-held Speak & Maths and Speak & Spell.

108. Both within the formal education sector and outside it, then, MEP has been under constant pressure to expand its role and services from the very beginning. In spite of this, it gave serious thought to working out a strategy for maximising its impact and resisted the demands from various quarters that it should produce early results at all costs. The first year of MEP's operation was marked by considerable criticism, much of it ill-informed and premature. Nevertheless, the Directorate stuck to its strategy even though it was bound to require an apparently "fallow" period while delicate negotiations were undertaken and the seeds of long-term collaboration sown.

109. By mid-1983 the patient negotiation and preparatory work was beginning to pay off, as the first MEP Resources Catalogue demonstrated. In addition to a wide range of MEP-sponsored software and hardware was an extensive list of audiovisual resources: BBC radio programmes, tape/slide programmes on telesoftware in education and modular control, 20 videotapes and various classroom case studies on audiotape. The second edition (published by Tecmedia in Spring 1984) testifies to further progress and diversification.

110. A notable feature of MEP has been the strength and success of its in-service training programme. The "cascade" model of training was to create a first wave of trained teachers who were then able to offer familiarisation courses in the regions to further teachers, who in their turn could initiate courses for others in their schools, using a multiplier effect to reach ever-increasing numbers. This was combined with the use of distance learning materials like the Microprimer pack (combining print, software and audiovisual resources) in order to meet the challenge of the simultaneous training needs of a whole generation of primary school teachers. This approach to the problem of accelerating and multiplying the impact of traditional in-service training has attracted worldwide interest.

The Open University and the Micros in Schools Project

111. Britain's Open University (OU) is a major resource for general education in NIT. It is best known as a provider of higher education at a distance: most of its 65 000 students are adults with jobs or other full-time commitments studying for degrees. However, a commitment to continuing education was written into the OU's Royal Charter, and by 1983, it offered a wide variety of short and introductory courses, specialised courses for industry and "post-experience" courses aimed at teachers and other groups. By late 1983, the OU was involved in some 20 major projects concerning computers and general education.

112. The Micros in Schools Project is primarily aimed at teachers. Of its £1 million budget, around half has been borrowed against future sales and half has been provided by MEP. The Project is to produce five packs: Awareness, Educational Software (P541), Micros in Action in the Classroom (P542), Microelectronics (P543) and Microcomputers (P544). The first three all emphasize educational software; their purpose is to make the teacher an intelligent consumer, aware of what is available and capable of making judgements about its suitability. The latter two packs include DESMOND, a battery-powered electronics kit, and incorporate extensive practical work.

113. A team of four full-time programmers/analysts are producing software for five microcomputer systems: the BBC Model B, Sinclair Spectrum, Apple II and the two Research Machines (380Z and 480Z). Around 75 per cent of the material is general, 25 per cent machine-specific. The Awareness Pack appeared first: it consisted of three booklets (a Study Book, a Project Book and Case Studies) and software cassettes (containing four programs).

114. The Case Studies booklet contains 13 portraits showing how computers are actually being used in classrooms. The style is vivid and the selection of examples varied. Unfortunately, some of the most interesting applications use hardware and software which is not yet widely available, but the booklet is an excellent resource for helping to enlarge people's thinking about how computers might be used.

115. The Project Book is essentially a guide to the software, though it also contains a guide to evaluating software and a good glossary. Four programs are supplied: EUREKA, TURTLE, INTEREST and SERVICE. EUREKA shows graphics of a man having a bath. The user controls the bath taps, plug and his movements in and out of the bath, and can plot a graph of the water level. The program can be used as an electronic blackboard, a simulation or to pose a detective-style mystery. TURTLE gives the user access to the LOGO programming language (see section D). Although it is only a partial implementation of LOGO graphics, this provides an easy introduction to programming in a high-level language.

116. INTEREST is a program-within-a-program, designed to show the operation of counters and loops in slow motion during the step-by-step execution of a simple BASIC program. Users "walk through" the 10-line program at their own pace, and see how it calculates compound interest. Meanwhile the program is displayed together with the current values of all its variables. Finally, SERVICE is a queueing simulation set in a fast-food take-away restaurant, with graphic display. The user can vary parameters like the number of helpers and length and timing of their rest-breaks, and discover the effect on waiting

time, customer satisfaction and profitability. Apart from the obvious application to business studies, the exercise illustrates the uses and limitations of computers for simulating real-world events.

117. Overall, the Awareness pack sets a high standard of presentation and provides some interesting material. It does not substitute for the sort of practical training provided by MEP's in-service packs, nor does it help its users with mundane but vital computer skills like disc handling or formatting. It does, however, successfully concentrate on positive thinking about the contribution of computers to education.

G. Computer Literacy for a General Audience: the BBC Projects

118. The BBC Computer Literacy Project was launched in 1982 by the Continuing Education Department of the British Broadcasting Corporation. It was a complex project on a vast scale with a target audience of millions, if not tens of millions. The main element of the first phase was a series of ten television programmes, the commissioning of a microcomputer from Acorn Computers Ltd., a self-study course devised by the National Extension College (NEC) and supported by tutors and study groups operating through local centres, and the Computer Referral Service which puts members of the public in touch with over 1 000 local sources of help. General support and advice was given by the Microelectronics Education Programme whose Regional Information Centres were involved from the beginning.

119. Various materials were published in conjunction with the Project -- notably two books which have both sold over 100 000 copies: The Computer Book (BBC Publications, 1982) is a well-illustrated and readable introduction to the whole field and Thirty Hour BASIC (NEC, 1982) is a self-study programming course. BBC Publications also published software associated with the television broadcasts, and its teletext service CEEFAX broadcasts telesoftware to those who bought the teletext decoder unit (released in 1983 at £200).

120. The Project's main aim is to demystify computers by building understanding through practical experience. It was realised through a complex web of collaborations with organisations of different kinds: thus the BBC (a state-owned corporation) enlisted a private enterprise (Acorn Computers Ltd.), a non-profit-making trust company (NEC), an independent educational charity (Broadcasting Support Services) and a government-funded agency (MEP).

121. The first series of ten TV programmes (The Computer Programme) provided a general introduction to the hardware, software and applications, with simple illustrations of BASIC programming built into each programme. The presenter, Chris Serle, represented the layman with no previous knowledge or experience, being guided through the various obstacles by a computer expert. Studio sequences were illustrated with screen shots and captions, interspersed with films sequences of real-world applications from the corner shop to international airlines. About 1 million people watched each programme and about 7 million saw some part of the series first time around. Generally, it was well-received, although an appetite for greater detail was evident among parts of the audience.

122. The *Computer Programme* series was first transmitted in January 1982 and was soon repeated in the UK; it has since been networked in the United States, Australia, New Zealand and several countries in Asia and Europe. The follow-up series (*Making the Most of the Micro*) was aimed at "users or potential owners" of microcomputers and also at "a general audience of the technically curious". It was first transmitted in January 1983 and quickly built up a total weekly audience of around 3 million viewers. It was widely used in recorded form by schools and colleges. The second series assumed some familiarity among viewers and looked in more detail at topics like string handling, graphics, data bases, control and business applications. Subsequent series have included *Computers in Control* and *The Electronic Office*.

123. Perhaps the most controversial feature of the Project was the BBC's decision to commission its own Micro. The rationale was the perceived need for a machine of British design and manufacture, easily expandable and relatively "future-proof", with a good keyboard (adequate for word processing), capable of sound, colour and "high resolution" graphics, and with a resident dialect of BASIC which combined as much compatibility as possible with previous BASICs with the ability to support powerful extensions. Apart from those critics who are opposed to any dialect of BASIC on principle, most people find BBC BASIC surprisingly powerful and flexible. Other languages such as LOGO, MicroPROLOG and Microtext are rapidly becoming available.

124. Now that the technical and production problems which dogged its first year have been overcome, the BBC Micro has been widely adopted by the British educational establishment. Growing amounts of commercial and MEP-sponsored software and training materials have been published. This support has tended to accelerate exports, especially to the English-speaking world. A consensus view might be that it is a well-designed machine, with a question-mark in some minds over supplies, dealer support and reliability. Sales approaching 250 000 were reported by Spring 1984.

125. There has been a variety of follow-on projects mounted by different departments of the BBC. 1985 will see the launch of a follow-up project with broader scope, covering the whole field of information technology. Called *For Your Information*, it includes an illustrated BBC Publications book, specially designed software, a radio series to be broadcast in Spring 1985 and a new syllabus created by the City and Guilds to provide certification for anyone participating in the project.

H. Some Examples of Permanent Structures

126. This section describes two relevant permanent structures, one from France and one from Italy.

Centre Mondial Informatique

127. The Centre Mondial Informatique et Ressources Humaines is the realisation of a very ambitious project conceived in the late seventies by an economist interested in reducing the gap between industrialised and developing

countries through the use of electronics and informatics.

128. The Centre was able to attract several international scientists. Although some of the international staff were not able fully to accept with the growing needs of the French nation for NIT literacy, most of the CMI projects still carry a great concern for a humanistic view of technology.

129. CMI serves at least three different functions with different operational strategies. The first, visible to visitors to the Avenue Matignon, is an open space filled with microcomputers of various kinds. This is aimed at casual visitors but is also available for schools and organised groups wanting to pursue more structured objectives. In this way CMI serves the same functions as the Capitol's Children's Museum on a smaller scale. The second function of CMI is to carry out advanced research on educational technologies of the future, such as interactive videodisk. Thirdly, CMI promotes large-scale projects in NIT jointly with other national and international agencies. This role has already emerged in earlier sections of this report.

130. CMI started its operation in 1981 with an annual budget of some FF 100 000 and a permanent staff of more than 50. Its short-term objectives of promoting literacy through NIT projects are well integrated with long-term ones. CMI represents the first deliberate attempt to set up an international research and development Centre on general education in NIT. Maintaining a balance between urgent domestic needs and long-term international objectives is a perennial problem. CMI's partial failure to achieve fully-fledged international status only underlines the question for other countries: how far can and should CMI's research be replicated elsewhere?

FORMEZ: An Italian Adult Education Agency

131. FORMEZ is funded to promote educational projects to promote economic development of the south of Italy; it is also the biggest public agency for adult education in Italy. It sets high standards both for its staff and in the quality of its products which are disseminated through other agencies in Italy.

132. With an annual budget of some $20 billion, FORMEZ has produced many relevant educational packages in the field of general education. For example, ELEC is an audiovisual introductory course (ELementary EConomy), and there is a multimedia course in general education for adults with interesting modules on anthropology, science education, public administration, commerce, and international relations. Schools and non-profitmaking cultural organisations located in the south of Italy are entitled to get copies of FORMEZ educational products at a nominal price.

133. FORMEZ has a structure of nearly 200 Adult Education Centres (AES) throughout the south of Italy which are open to everybody who wishes to consult the multimedia library. Every year the AECs organise a comprehensive set of conferences. Special courses related to major FORMEZ products are held for selected groups of young adults, often in connection with their change of status in the labour market.

134. Many FORMEZ projects already combine different media and educational strategies effectively. Not surprisingly, FORMEZ intends to invest in new

information technologies both as a medium and as a goal within general education.

135. At the level of general understanding, FORMEZ planned a new edition of a very successful audiovisual course, the "Corso di Cultura Generale per Adulti" (General Education for Adults or GEA) with a considerable emphasis on information science and technology.

136. The audiovisual version of the course was to be finished by the end of 1984 and was to contain sections on knowledge, science, common sense; communication; computer science; and information storage and dissemination.

137. A computer-based version of some FORMEZ audiovisual packages in MicroPLATO is being developed jointly by SISCO, Control Data Corporation and SYNTAX, an Olivetti-owned research company. Other plans include the use of a more sophisticated integrated workstation with a videodisc-based catalogue of educational products, to be used in the AECs for self-study and course planning.

138. The educational philosophy underlying most FORMEZ packages is taken from Dewey and Montessori. Thus the GEA course starts from common sense and everyday experience and leads on to alternative interpretations of the evidence. New knowledge is accommodated through active learning methods, not by passive reception. The educational material is primarily intended as a stimulus to discussion and the exchange of views. The GEA package does not intend to promote mere acquisition of knowledge about the information society, but a deeper understanding of its implications.

139. GEA courses are run for groups of 20 young people with a tutor. The classes are open to everyone aged 15 and upward; no formal qualifications are required. Some will be unemployed, others in jobs. The courses are not intended as vocational education nor are they linked to the school curriculum. They are a major contribution to general education for adults in the information society.

Chapter III

NIT AND GENERAL EDUCATION: THE ISSUES

140. In Chapter I we discussed NIT's potential for enhancing human learning. New methods and delivery systems which capitalise on NIT can bring education within the grasp of people who were previously disadvantaged by age, circumstances, distance or other handicaps. This immense potential for innovation is combined with a profound challenge to the assumptions, practice and even institutions which prevail in formal education. We begin by identifying some aspects of that challenge.

A. NIT and Formal Education: The Challenge

Curriculum

141. NIT underlines the rapid obsolescence of any kind of curriculum. In fact NIT may even question the very importance of a curriculum such as it stands now. The definition and "implementation" of a new curriculum requires nowadays a very large amount of time and resources. By the time a new curriculum is conceived and formally approved and begins to be "implemented" in the educational system, it is very likely to be already obsolete.

142. Vested interests in teaching particular subjects obstruct attempts to bring the school curriculum into the 20th century. Even in subjects as recent and as rapidly-evolving as computing, teachers seem inclined to teach their subject from its historical beginnings, so that content accumulates at the price of mastery of method. The commitment to teaching discrete subjects in secondary schools is one of the obstacles to the establishment of NIT both because of the problem of identifying what is to be displaced and because the impact of NIT is (or ought to be) felt across the board.

Methods

143. Traditional teacher-centred class teaching methods contrast unfavourably with possibilities revealed by NIT, both in their ability to cope with individual differences and in their appeal to the students. Already highly motivating use of colour, animation and sound effects can be combined with individual interaction, diagnostic feedback on errors and management of

progressive difficulty levels. Although much "educational" software has failed to capitalise on these possibilities, software publishing is in its infancy and improvements can be expected. In the near future, affordable interactive video will offer all the realism of live sound and movement combined with the individual responsiveness of the computer. Also imminent is the diffusion of software embodying expert systems with intelligent language handling: the Socratic dream of having an expert tutor to oneself, able to converse in natural language, cannnot be far away.

Delivery Systems

144. Traditionally, formal education has been delivered during fixed hours, in pre-determined places, with courses beginning in fixed months of the year. Previous qualifications are sometimes demanded, and there may be age restrictions. NIT calls all of this inflexibility into question. Given suitable equipment -- e.g., a cheap microcomputer, standard television, telephone and modem -- there need be no artificial barriers to learning. Why should not the elderly, the disabled, those in ships or prisons, people on remote islands and mothers housebound by infants all have access to the same courses and examinations as the stereotype of the 18-year-old mobile bachelor for whom residential university education is traditionally designed? Naturally, some educational objectives require attendance at some kind of local centre, whether to gain access to specialised equipment, for face-to-face interaction with other students or the tutor or because home conditions make serious study difficult or impossible. But once the possibilities of NIT have been fully understood, it is remarkable how few of the conventional restrictions can be defended rationally, and what a high proportion of needs can be accomodated on a flexible basis offering more convenience to students.

Teacher Training

145. NIT has created a crisis of credibility for teachers of practical subjects without recent business or industrial experience. To take a single example, there are still teachers of secretarial studies teaching shorthand to pupils who will emerge into a job-market where even dictation equipment is being superseded by voice-entry word processors. More generally, there is an acute problem of how to update and retrain entire generations of school-teachers whose initial training excluded any mention of computers. The United Kingdom Microelectronics Education Programme has successfully demonstrated the promise of high-quality distance learning materials for a crash programme of in-service training. Even so, there is a large gap between the teacher whose experience is confined to a short self-study course and the calm confidence of the experienced home computer user. Remembering that the latter may be seven years old and the former paid to teach him or her, it is easy to see why so many teachers view NIT with apprehension.

146. The initial training of teachers presents an equally pressing problem; teacher trainers are sometimes even less familiar with NIT in modern business and industry than the student teachers they are expected to train. The general contraction in teacher education has reduced the influx of new blood, and inducements to early retirement have meant the loss of many lecturers with outside interests and an entrepreneurial flair. Nevertheless, any programme

for re-educating teacher trainers depends on motivation and consent for its success. If it is imposed from "on high" it is bound to fail.

147. Teachers' and teacher trainers' desire to learn about NIT is re-inforced by the knowledge that if they do not adapt, they will be by-passed. If it really takes 50 years for a suggested innovation in teacher education to turn itself into classroom practice, then alternative means must be found, because in another 50 years NIT will be unrecognisably different. Some straws in the wind were documented in the case studies: Delmas reported that in the case of the "Holidays for the Future", often the least well-trained instructors were the most enthusiastically accepted. He also described the growth of the twilight world of unofficial clubs where peer learning/teaching is the norm, with small advertisements and informal networks replacing the apparatus of formal schooling. Megarry commented upon the significance of the massive government ITeC initiative having by-passed the formal education sector and using staff who would not be acceptable within the school system. Recent observers have pointed towards a trend towards deprofessionalisation of the traditional white-collar careers; NIT may hasten the process within teaching. Its sheer urgency underlines the difficulties that the education system has in accomodating rapid change.

Education and the Life Cycle

148. Formal education has hitherto been committed to the "front-end model" of administering a single dose of education early on in a person's life, after which that person is apparently considered "educated". Apart from the obsolesence of the knowledge available, it is increasingly obvious that adolescence is not the only, and probably not the best, time in a person's life to offer educational opportunities.

149. Information science emphasizes the need for lifelong learning (education permanente) as well as providing appropriate methods for obtaining it. The problem of information overload provides a telling argument against the front-end model of education. For example, the number of scientific journals published has grown exponentially -- from two in the mid-17th century to 100 in the mid-18th to 1 000 in the mid-19th century. Nowadays between 30 000 and 100 000 are published -- 6 000 to 7 000 scientific articles each day. As Morgenstern remarked, if the publications on physics were to continue to increase at their present rate, within the next 150 years the total weight of the paper would exceed that of the earth! Clearly it is no longer possible for any individual to master all aspects of a subject within a single lifetime. Instead we must accept the idea that updating knowledge is a permanent requirement, and harness the power of NIT to help us locate and process information when we need it, e.g. using on-line data base searches and expert systems.

Effects of the Job Market

150. The employment market is contracting and changing its nature, reinforcing the case for education continuing throughout adult life and for transforming the relationship between general and vocational education. In a world of obsolescent skills and industries, with microelectronics and NIT affecting job content and the exercise of traditional skills, there is clearly

no longer any role for narrow job-related training in schools. Instead, education must prepare pupils for a society where vocational retraining and career changes are the norm, where self-employment, freelance work and job-sharing are commoner, and where mass structural unemployment may continue to take its toll of human misery and indignity.

151. For the pessimist, "education for leisure" conjures an Orwellian image of masses of people turned into passive recipients of NIT services and products, mindlessly hooked on home entertainment provided by extended television/videotex/interactive cable services. A more optimistic view recognises that the boundaries between leisure activity, education for self-improvement, voluntary (unpaid) work and economic activity are all socially defined. At present, creating and using computer software may fall into any of these categories for different people -- or even for the same person at different times. If automation, robotics and NIT create sufficient wealth, new consumer demands and leisure/education industries will continue to create opportunities for part of the population to consume goods and services provided by another part. We may all become consumers of leisure/education for far higher proportions of our day/week/year/lifetime than hitherto.

152. Suppose that by the 21st century, many citizens in OECD countries can support themselves comfortably by working for (say) 480 hours a year. Whether this is arranged as 12 working weeks of 40 hours each or 48 weeks of 10 hours each, it clearly will present unprecedented opportunities to make productive use of the remaining waking hours. The time could be used to learn woodworking or a musical instrument, to teach a friend to grow plants or cook, to enrol for a recognised qualification in small boat navigation, to write letters to friends or articles for publication, or in caring for young children and helping them to learn. In some of these, NIT will have a crucial role, in others it might be almost irrelevant. The challenge for educators is how to ensure that NIT increases the individual's autonomy and self-directedness, rather than simply providing mass "entertainment" in a wired society.

153. In the light of all of this, it cannot be assumed that schooling (in the sense we understand it today) will survive indefinitely. It is too soon to predict what form the alternatives may take. Some clear thinking about what educational processes do and do not require physical proximity is urgently needed. However, it is not our purpose to bury the school prematurely. The elements of compulsion and universality play a crucial role in redressing the different kinds of inequality addressed in the next section.

B. NIT, Equality and Disadvantage

Sex

154. Throughout the case studies, a recurring theme was the underachievement and underparticipation of females of all ages in NIT. This is further documented in the World Yearbook of Education 1984: Women and Education (Kogan Page, 1984). Women's traditional skills of patience, dexterity and accuracy mean that they dominate low-paid NIT jobs like data preparation, word processing and telephone switchboard operation, but they have made

surprisingly small inroads into computer programming, systems analysis and software design. Whenever female aptitude for such jobs is tested, it is found to be at least equal to that of males. So the explanation of imbalance is not unequal ability.

155. During the years of impressionable adolescence, girls struggling to achieve a sense of feminine identity have to make choices (often perceived as irrevocable) about subjects to study and courses to pursue. Computers have an image influenced by their history of "male" concerns: wartime code-breaking, the space race, big business and high-technology industry. Computer games sold for "entertainment" display a depressing preoccupation with warfare and destruction. Whether this merely reflects or actively reinforces the interests of their purchasers, the combined effect is that computing has a strongly masculine image. This is reinforced in young minds by the tendency of men to be the ones who own, use and teach others how to use computers. None of this is inevitable: Megarry described how the INTER-ACTION Community Camps managed to reverse the usual sex ratio by deliberate marketing decisions. But this does require a conscious effort: thoughtlessness probably contributes more to sex-stereotyping than does outright prejudice.

156. Most developed countries are very short of talented NIT workers. Given the enormous industrial and strategic importance of this field, with massive government investment and keen international competition, it does seem wasteful to discourage (however unintentionally) the participation of half the nation in this way. The spread of microcomputers into primary schools (where they are operated mainly by female teachers) should help to dissolve the current association in young minds. Widespread adoption of creative and open-ended software in the arts and humanities would also help to dissociate computers from the mathematics and science departments of secondary schools. Making computers and NIT an integral mainstream part of the compulsory curriculum would help to prevent girls from opting out, but where the computer club is optional, self-selection will militate against equal female participation.

157. Special thought must be given to the problems that once-qualified women encounter when trying to re-enter the job market after a gap of some years, usually caused by the assumption that women must interrupt their careers for domestic reasons. No field could be more forbidding to the re-entrant than NIT: an absence of even three years may be equivalent to several decades in other occupations. A general expansion of retraining opportunities would help. In the longer-term, the development of more flexible ways of combining infant and child care with part-time employment of "permanent" status could remove the necessity for women to lose contact with the NIT field. After all, computer literacy can be of immediate benefit to a baby's mother: simple programs can create fascinating interactive screen displays with far more educational value than passive viewing of a television screen!

Age

158. It is widely assumed that NIT belong to youth. There may be, in fact, some valid reasons to explain why young people are more attracted by some motor, perceptual or even intellectual mechanisms in a way that is never parallelled later on. In fact the motor control of fingers on the keyboard and of the eye movements on the screen may be greater at a younger age than

in later life. Perhaps even the ability to analyse and recognise complex visual patterns on the screen is greater at a young age, thus enabling young people to master more rapidly and efficiently graphics, animation and concurrent phenomena.

159. The natural inclination to play games and lesser concern for the management of personal resources (including time) are perhaps other reasons that may provide a good explanation of this supposedly strong relationship between youth and computers. The ability to master large bodies of organised knowledge and to allocate personal resources to meaningful objectives, however, is probably far greater in adults than in children.

160. We do not have enough evidence to prove that the relationship between young people and NIT is significantly stronger, but we should investigate, on the other hand, whether this supposed relationship does not hide any intention to exploit an ample and low-cost manpower resource. It is already only too common to find young and talented programmers being hired for next to nothing, or to be used without being paid for software demonstrations for commercial reasons.

161. It should perhaps also be investigated whether the ample and ever-growing market of commercial education in the field of NIT does not hide a large business and at the same time the idea of lowering the cost of manpower by creating an artificial surplus of programming skills.

162. There is ample evidence that adults have and retain the ability to learn new skills and concepts, including mastering whole new bodies of knowledge to a high level, well into what has been regarded as "old age". The fact that mathematicians are unlikely to do their most original work past the age of 30 is as irrelevant to the lives of ordinary people as is the observation that women are unlikely to win Nobel prizes for science.

163. The reasons why older people are less likely to embrace NIT are similarly historical, cultural and sociological, rather than biological or inevitable. The increasing proportion of the population above the official retirement age may bring about a re-examination of the attitude barriers which associate youth with NIT. Learning practical computing is above all time-consuming, and many senior citizens have time on their hands. Delmas remarked that some of the heaviest videotext users in the Velizy experiment were pensioners. Given the opportunity and the incentive, "retired" people's wealth of experience of human beings and organisations could make their contribution to NIT particularly valuable.

Money

164. It is difficult to generalise about the importance of money as an obstacle to equality. There is no doubt that possession of a home computer system breeds confidence in computer users which confers upon them a massive advantage in acquiring competence. The greatest thing to fear in learning about NIT is fear itself. The opportunity to experiment and make mistakes in the privacy of one's own home is a great confidence-builder, and it follows that children from computer-owning homes are at an "unfair" advantage. (It is interesting that several large firms and education authorities wanting to

spread computer literacy among executives and teachers have recognised this by a deliberate policy of home loans.)

165. How expensive -- and how unfair -- is this advantage? In Britain, it is estimated that 11 per cent of homes will have at least one computer by the end of 1984. If you already have a television and a cassette recorder, serious home computing may begin at around £130 (the price of a new 48 K Sinclair Spectrum) or less; this is around the national average weekly wage. If you already have a telephone, access to interactive videotex (Prestel) costs another £100 for the modem (excluding running costs). Making effective use of all this is another story. Serious programming demands a printer, faster external memory than a cassette recorder provides, a monitor so that the computer user is not dependant on time-sharing the family television, a permanent set-up with the furniture and space to accomodate it, not to mention software, paper and blank tapes and disks. Word processing demands a proper moving-key keyboard and may invite a better-quality printer. From £1 000 to £1 500 would be more realistic for a working personal computer system at 1984 United Kingdom prices. Thus computers may be cheap but computing is still expensive.

166. Even so, many British families will spend more than £1 000 on the annual family holiday, and sometimes much more on a new car. The word "expensive" says as much about the purchaser's attitude as it does about price. Middle-class families are more likely to see a home computer as an investment in the future, the 1980s equivalent of a children's encyclopaedia, and perhaps also to imagine that they will learn to program it "some day". Advertisers have not been slow to exploit middle-class anxiety that their children may be "left behind". Some of the micros bought in this spirit are never used, the parents having seriously underestimated their children's interest or the time and energy required to produce worthwhile results. Nevertheless, there is no doubt that children whose parents are able and willing to afford a home computer are at a significant advantage. How far and by what means should the state try to redress the disadvantage of those who cannot expect this facility in their homes?

Social Class

167. The extent to which higher socio-economic groups tend to predominate in NIT initiatives is in many ways a paradox. After all, the alienation of working-class children from formal education is often explained in terms of an academic curriculum deriving historically from upper-class culture and a teaching force that embodies middle-class values, attitudes and language habits. By contrast, micros employ the archetypal symbol of mass culture: the television. Computer games often resemble electronic fruit machines and space invaders. Because computers involve people in practical activity, they offer ways of making abstract concepts like syntax, logical deductions and geometry into concrete events like the failure of a program, a screenful of garbage or the movement of a Turtle. Thus, the argument runs, the working-class child ought to feel more at home with computers than with books, and the relentless logic of the computer should combat any tendency among middle-class teachers to confuse refined speech or elaborate verbosity with ability.

168. Yet the case studies clearly demonstrate that microcomputers are not releasing working-class talent on the expected scale. Possibly it is still too soon to expect results; probably the greater likelihood that middle-class children have access to a home computer is still a factor. But perhaps part of the answer lies again in the image of NIT, a feeling that "this is not for us".

C. NIT and the Information Society

169. NIT is a largely unexplored continent to most of the world's population; concealed by its esoteric language and subculture, it is perceived as populated by a superior race. The computer professional is traditionally seen as a highly-motivated (perhaps mildly obsessional) person of little culture or aesthetic sense with an overdeveloped interest in cold logic and clearcut decision rules. Like all stereotypes, this one is often far-wrong in individual cases, and ought to be reviewed continually! However, surprisingly little attention has so far been paid to the social and cultural effects of NIT on the host society. We must anticipate a world in which computers and NIT are as mainstream and as firmly embedded in the fabric of society as is the motor car now -- a world in which the diehard computer enthusiast will be seen to be as eccentric as the self-taught motoring pioneers of the 1920s might appear today.

170. The comparison between motor cars and computers is instructive. Formal education tends to neglect the motor car as a subject for general education. This is not because motor vehicles are unimportant in society, but because developed countries already offer such a rich environment for young people to learn about motor vehicles and their impact. The vocabulary of traffic congestion, automatic transmisson, motorway regulations, air pollution, body aerodynamics and tyre pressures does not need to be taught as a school "subject". It is inhaled with the atmosphere of a motorised society, picked up through direct experience of family motoring or public buses and coaches, reinforced by the mass media, and ultimately, for many, formalised in the passing of a driving test and eventually car ownership.

171. If NIT had developed over a century, it might have been possible to create an equally rich and equally natural environment for people to learn about NIT as part of growing up. But the pace of change demands purposeful campaigns, not laissez-faire.

CONCLUSION

172. The computer is morally neutral: a force for good or evil, depending on how it is used. But it is also a once-in-many-centuries invention of immense potency. Its extension into NIT was both technologically and commercially inevitable. The values of society can only be safeguarded if NIT literacy is widespread in the general population, among politicians, administrators, housewives, shopkeepers and trade union officials. NIT devices and networks must be made transparent to ordinary people. Otherwise citizens' and politicians' legtimate concerns will be pre-empted by the technocrats of the NIT industry.

173. For most people, the hardest part of the journey towards computer literacy is taking the first step. Once started, success and confidence breed more success. There is thus a strategic as well as an egalitarian argument that general education in NIT should aim at helping as wide an audience as possible to surmount the initial threshold. The BBC Computer Literacy Projects have demonstrated the success of such mass campaigns, and illustrated how quickly erstwhile novices can give others basic induction while continuing to increase their own knowledge and confidence. A rapidly increasing pool of people with a good basic grasp of the principles and an attitude of being unafraid is a healthy base upon which to build the foundations of an information society.

174. This task is urgent. Society has yet to catch up with the implications of the first generation of computers. Already cheap artificial intelligence in the shape of fifth-generation computing is imminent, electronic networks are proliferating, massive data bases are being combined clandestinely and citizens' rights are continually being eroded. Governments and big businesses are not immunne: the computer frauds and security breaches which are reported are clearly only the tip of a large iceberg, and the ease with which schoolchildren have been known to break into US defence computers illustrates a potential threat to national security. Meanwhile, the number of components packed onto each tiny chip of silicon continues to double each year, dramatic reductions in the size and price of computer memory continue, digital electronics, videodisc technology and telecommunications innovations continue to converge, and recent advances in biotechnology promise to pose a fresh set of social and ethical problems.

175. It is later than we think. Information technology is here and now. It is much too important to be left to NIT professionals.

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NEW TEACHING FUNCTIONS AND IMPLICATIONS FOR NEW TRAINING PROGRAMMES

1. The attached document has been prepared by Rhys Gwyn, Principal Lecturer, Manchester Polytechnic, United Kingdom, in his capacity as consultant to the Secretariat. It will serve as a background report for Working Group 4.

2. The views expressed are those of the author and do not commit either the Organisation or the national authorities concerned.

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1. This report, prepared for the OECD/CERI Conference on Education and New Information Technologies pays specific attention to one of the sub-themes of the Conference, namely the implications of the adoption of the new technologies for teacher functions and for the education and training of teachers.

2. Given the extremely rapid evolution of educational responses to the NIT and the diversity of strategies being adopted, any such report must be, inevitably, both subjective and limited. The author therefore accepts full responsibility for any orientation to the report which is seen as partial or as a purely personal viewpoint -- indeed, the report is written in the belief that one of the problems to be faced is that currently, at national as well as institutional and individual levels, we are all operating on "personal" viewpoints. What is claimed here, in defence of the views expressed, is that they are at least based upon many years' experience of studying the education and training of teachers at the European level and also upon a number of years spent examining, again at European level, the impact of the new technologies on teacher training.

3. In this latter context, it is a pleasure to put on record the immense benefit gained from working, over a period of five years or so, with colleagues in the Information Technology Working Group of the Association for Teacher Education in Europe (ATEE). Debate within this group has never been less than lively, and has made it very clear that when we talk of inserting the NIT into our education systems and our educational practices, we have to remember that our systems and our practices do in fact differ quite widely one from the other. Even when considering the countries of Western Europe alone, we ignore at our peril the cultural differences between our various definitions of what it is to be educated. In the wider context of OECD membership, the caveat becomes even more important. Despite these differences, however, debate with colleagues in the ATEE group has been a constant stimulus to thinking and has, inevitably, left its mark on the observations put together here.

4. Another debt which it is a pleasure to acknowledge is to the colleagues who wrote the Country Reports upon which this paper has drawn so heavily. Their papers are a mine of information about the present situation in their respective countries, and without them, this synthesis report would have been

far more superficial and impressionistic than it is. The authors in question are (for France) M. Jean Valérien, (for the United Kingdom) Mr. Maurice Edmondson and (for the United States) Professors Robert D. Hess and Irene T. Miura of Stanford University, and Professor Nolan Estes, of the University of Texas at Austin. Two more reports were expected, but were not available by the time the present analysis was prepared. Possibly they will be included in a final version of this report.

5. These debts notwithstanding, it has to be said again that the views, omissions, errors and distortions found in this Report are the responsibility of the author and of the author alone.

INTRODUCTION

1. This report examines the impact of the new information technologies (NIT) on educational practices in OECD Member countries. It focusses especially upon the changes to which the new technologies point in the functions of the teacher, and also upon the implications of these changes for teacher training. As will become evident, however, it is not possible to construct such a focus in isolation from consideration of other important factors, notably the developments taking place in the technologies themselves and our growing understanding of just how wide some of the implications of the NIT might be for education; factors such as these will have an important bearing on the analysis offered here.

2. It is clear, from background papers to the OECD/CERI Project as well as from other sources, that the current effort being made by most Member countries to construct educational responses to the challenges of the NIT are little short of dramatic. The level of investment, in terms of both capital equipment and manpower, is remarkably high in many countries, and this at a time of general economic recession. Returns to the Project questionnaire provide clear evidence that this investment is the concrete reflection of a real concern to formulate a response to what is increasingly defined as a very large challenge indeed. Given that the current complex of activities dates largely from only the very late 70s (though earlier, mainframe-based, developments such as those of France and the United Kingdom were important) the word "dramatic" does appear to be entirely appropriate.

3. Nonetheless, it is necessary to recognise the complementary view that also emerges, again from both Project and other sources, namely that, despite the intense activity to which both human and material resources are so heavily commited, there remains a great deal more to be done in both the quantitative and the qualitative senses before we may begin to feel at all satisfied that the strategies emerging are adequate to take us and our pupils into the 21st century. The flavour of what has been achieved so far remains decidedly ad hoc (in the words of one United States paper, "at the local level, confusion appears to be the order of the day"). The relatively high levels of funding and of activity must not be allowed to disguise this fact.

4. That this should be so is scarcely surprising. The pace of technological development, as measured, for example, by the advances in the technical specifications of microcomputers available to schools in 1984, compared to those of 1980, has been extremely rapid. Keeping abreast of this pace of change is difficult, while the capital expenditure referred to above, in terms of hardware alone, is of a magnitude not easily inserted into educational budgets. Given, even more importantly, that arriving at an understanding of the educational potential of the NIT is a daunting task, it

is little wonder that national responses currently fall something short of fully co-ordinated policy.

5. What is currently encouraging is that priority areas for policy begin to be identifiable. The early emphasis, in many cases, was in fact upon the hardware and upon getting this into the schools as rapidly as possible. But Hamilton and Casserly (1983) point out, it was disturbing: "...that in some few cases the purchasing of equipment on a large scale had preceded the actual planning for what to do with it." But even when such short-sighted policies are adopted, however, it rapidly becomes clear that two other, very pressing, developmental needs emerge. One, which is extremely important, is the urgent need to acquire -- by whatever means -- software which actually has some educational value; a recurrent theme in country reports prepared for the OECD/CERI Project is the disappointing, and sometimes abysmal, quality of a great deal of the software available.

6. The second of the emerging priorities, and one with which this paper is centrally concerned, is for the training of teachers to use and develop the potential of the new technologies. Here there has been a dangerously circular dilemma. It is clear that the insertion of the NIT into educational use will -- or at least has the potential to -- bring about changes in the ways in which learning can be organised; that is to say, in the ways in which teachers function. We cannot predict fully the likely nature of these changes, partly because they are in any case notoriously complex, but also because there have not been sufficient teachers and, most importantly of all, makers of educational policy, with sufficient appreciation of the potential of the NIT to enable suitable forms of training to be established. It is a key problem. There is a very real sense in which it would matter relatively little if technological advance were to halt over night (it is of course unthinkable that it should) since there is sufficient implicit in existing technology to keep educationalists occupied for the rest of the century. But the full educational advance cannot and will not be made until a sounder understanding has been established of the new kinds of learning that become possible, of which of these are desirable, of their implications for the role and the functions of the teacher, and of their further implications for teacher education and training.

7. There is an important point implicit in the wording of the last paragraph: it resides in the deliberate emphasis upon the word "learning". For, while it is clear that the focus of this study is upon the teacher, teacher functions and teacher training, it is also essential to remember that the teacher is only a means to an end. The end is the education of the child. The danger of a focus upon the concept of the teacher is that it may engender the unquestioning assumption that, while minor modifications to the role may come about, the role itself will endure. This report is written in the belief that this is, in fact, the case, and that teachers will continue to be needed for the education of children for a very long time. But it has at the same time to be recognised that some of the potential uses claimed for the NIT do call in question the teacher role itself, while others postulate a change in teacher functions so extensive as to demand a major re-evaluation of that role. The emphasis on the centrality of the learning, rather than the teaching process, will help to maintain these possibilities in focus. It seems appropriate here to quote the words of the President of the French Republic: "Les Cahiers de l'Education Nationale" for December 1983 quotes M. Mitterrand as having said (at the colloque "Informatique et Enseignement"

which took place in Paris on 21st and 22nd November 1983): "...l'informatique n'est pas un domaine supplémentaire d'enseignement ; elle transforme la manière même d'acquérir les connaissances... " It is a salutary reminder.

8. Subject to this proviso, this study attempts to analyse the changes demanded by the NIT in teacher functions and in teacher training. Of necessity, it is prospective as well as descriptive. There is a widespread agreement that what has happened so far represents only the first steps and that a great deal more needs to be done; rather surprisingly, there appears to be an emergent consensus of opinion as to what the next steps might be. While such a consensus is by no means complete, it does allow for a responsible attempt at analysis to be made.

9. There does remain, however, one final and very important caveat to what follows. The remarkable level of financial investment, the greater part of it from public funds in all the countries concerned, has been mentioned already. There has been no precedent at all for such a large-scale insertion of capital technology into the school system. But what needs to be examined carefully is the possible unreality, of the present situation, since it is highly possible that those of us who attempt to project the development of the NIT in education, and who do so purely from an education standpoint, may be living in a fool's paradise.

10. Two interpretations are possible. There is the generous interpretation, which sees the investment as evidence of the overwhelming desire of governments (whether national or local) to see to it that education benefits as rapidly as possible the advent of an exciting new technology. There is the less generous view -- some would say cynical -- which sees what is happening as evidence merely of the strong motivation of nation states to safeguard their economic futures by investing in the technological training of their young. Certainly the popular and educational journalism of three of the countries involved has contained frequent references to the need to keep ahead or at least abreast of the Americans/the British/the French (depending on which of the three countries is the country of origin of the journal concerned); all three of the Western countries' literature refer to the need not to "fall behind the Japanese". If there is any truth in this cynical interpretation of the situation, then it is worth remarking that the financial bubble may burst. The intense interest of the NIT, from the point of view of the educationalist, is that they are ideally suited to supporting the teaching/learning processes. And it is already clear that there are yet further areas of development opening up which are of even greater interest for education: the growth of laser- (video-) disk encoding is a case in point. Such developments, however, are likely to be even more demanding upon resources than those known to us today, and it may well be the case that the level of investment demanded will go beyond what public funding will sustain, should a narrower focus be felt to be adequate for purposes of national economic advancement. There is no means of knowing whether such a scenario is realistic or not, but, given the present need to engage with an analysis which necessarily includes the prospective, it is salutary to bear in mind that the present climate of investment may just be that of a honeymoon period, and that there is no visible guarantee that funds will continue to be available to education on the scale of the present. The remainder of this report will be based on the tacit assumption that investment will in fact continue, but the making of this assumption should not obscure the extent of the act of political and economic will required.

Chapter I

CHANGES IN TEACHER FUNCTIONS: THE CURRENT PICTURE

11. A great deal of the educational development which has so far taken place in response to the emergence of the NIT has been ad hoc in nature. This is demonstrably the case where grassroots activity has been predominant, with individuals and small groups of teachers attempting for themselves to construct educational uses of the new phenomenon; it is also the case even where a lead has been taken at a higher level, say that of the municipality or a regional authority. That is to say, all such developments give the impression of being motivated more by an urgent need to initiate an activity (and, perhaps, to be seen to initiate an activity) than by a desire to produce a carefully thought-out strategy that would make proper use of the new resources and facilities coming into being. Nor do schemes at national levels offer a markedly different picture: both the Microelectronics Education Programme (MEP) in the United Kingdom and the national programme in France concentrate on partial approaches only to the total phenomenon. Given the rapidity and complexity of development of the phenomenon in question, this situation is scarcely surprising -- though not one which should be allowed to continue much longer. For these reasons, it is to a large extent easier and more interesting to construct a prospective picture of likely changes in teacher functions than it is necessarily to extrapolate from the evidence we have so far. Nonetheless, it is possible, even at this relatively early stage of development, to extract a number of learnings about likely changes in teacher functions from what has already happened in the growing use of the NIT in education. Although they originate in very different national contexts, the OECD/CERI background papers and reports are interesting in the extent to which they evidence already some broad similarities in the evolution of such functions, and it is upon these reports that many of the remarks which follow are based.

A. The Importance of Primary Education

12. In examining the implications of the NIT for teacher functions, however, we have to be clear as to the sense in which the word "teacher" is being used. The assumption will be made throughout this paper that the term "teacher" includes primary teachers, and, moreover, that the NIT have as much to offer at primary level as they do at any other level of our education systems.

13. This is a highly important point, and it would be idle to ignore that fact that it is to some extent controversial. It is clear from available evidence that, in a number of countries very little, or very little that stems from official policy, has been done to meet the challenge of the NIT at primary level. To go further: it appears to be the case that, in a number of countries, it has yet to be agreed whether, as a matter of principle, the NIT should be seen as having anything to offer at this level.

14. Here, one has to risk appearing dogmatic by stating categorically that this is a non-question. While the entry of the NIT into primary education in, for example, the United Kingdom and the United States is much more recent than at secondary level, more than enough has been achieved already to make it abundantly clear that the new technologies have a great deal to offer primary pupils and teachers.

15. It is not merely the much publicised claims of LOGO (Abelson and diSessa, 1981; Bossuet, 1982; Papert, 1980; Schwartz, 1981) which substantiate this point, though, to anyone who has worked on LOGO with primary children it is evident that this language alone has a major contribution to make to the learning of the young child. But work at the primary level, certainly in United Kingdom schools, extends far beyond LOGO alone. Extensive data base programs, word processing, adventure games and simulations -- as well as the ubiquitous drill-and-practice -- have all been tried and tested at primary level. It is against this background that it becomes possible to state categorically the role of the NIT at this level. It is a role which may be denied by policy decision, though it is difficult to see how primary schools anywhere can withstand the onslaught of the home computer. Indeed, for the primary school not to take heed of the "educational" software now finding its way onto the home computer market would be shortsighted in the extreme. Very clear evidence of the potential of the NIT at primary level emerges from not only the works cited, the authors of which are all of university level, though working with young children, but also from an extremely preceptive Headmistress of Pentland Priary School, Ms. Liddell, to the United Kingdom Background Report. In less specific detail, but drawing upon evidence from across the United States of America, reports prepared by Professor Nolan Estes, of the University of Texas at Austin and by Professors Robert D. Hess and Irene T. Miura, of Stanford University point clearly to the emergence of the microcomputer as an educational force to be reckoned with at primary level. The evidence is overwhelming: the questions concerning the insertion of the NIT into primary education are not "whether", but "how quickly?" and "how effectively?"

16. It is on these grounds that this report, in examining the implications of the NIT for the functions and the training of the generality of teachers, takes as axiomatic that its concern is as much with teacher at the primary level as with their secondary colleagues. Indeed, one can go further: if the new technologies are to make the major contribution to educational development of which they are capable, it seems essential that correct strategies be implemented from the outset. Such an implementation, in other words, must commence at the very earliest stages of learning.

B. The Emergence of the NIT Co-ordinator

17. When we look for concrete evidence of the new functions demanded of teachers, some very useful data is to be found in the emergence of what is essentially a new category of teacher, namely the person designated in a given school as the co-ordinator for insertion of the new technologies. Whether this be part of a national strategy, as in the cae of teachers trained under the French "long course" scheme, a condition of provision of hardware, as under the United Kingdom Department of Industry scheme, or a more spontaneous response to an identified need appearing in all countries, it is clear that there is a growing demand for some teachers (at least one in every school developing the use of NIT) to:

-- Be identified as "resource persons", knowledgeable about the NIT, to whom their colleagues can turn for informal advice;

-- Take a lead, more formally, in school-based in-service training;

-- Be responsible for the management of NIT hard- and software resources and of technical support staff;

-- Contribute to software design and development;

-- Advise headteachers and school managements on acquisitions policy as well as on longer-term education development.

18. The phenomenon is interesting, and widespread. It is referred to in a French background paper by M. Jean Valérien, dealing with developments in the Académie of Rennes; the "animateur" function is a recognised part of the strategy of dissemination in France. A case-study contributed by Mr. T.D. Pike, Deputy Headmaster of a boys school in Orpington, to the United Kingdom background report, on the other hand, shows how this kind of role has often developed from the enthusiasm of an individual. Not that all United Kingdom development is pragmatic; a contribution by Mr. W.R. Broderick to the same report shows how one English Local Authority planned for the creation of such a role. The United States reports of Estes and of Hess and Miura also refer to the important contribution made by this new category of teacher.

19. There is here, identifiably, a new cluster of teacher functions to be discharged, and a great many teachers, in diverse settings, are carrying an extremely heavy burden in an attempt to respond to the challenge. One may add that it is questionable whether the whole phenomenon of NIT in education would have left its launching pad had it not been for the quite extraordinary enthusiasm which the field generates in many teachers. The demands are remarkably onerous. Notoriously, the NIT phenomenon is not static; it is about as dynamic as it could conceivably be. Consequently, the "NIT co-ordinator" in a school must not only discharge all the functions identified above, but must also keep abreast of constant technological development. This does not necessarily require active participation in research in the scientific sense. But at the very least, merely to remain well informed requires, in the United Kingdom, perusal of at least some of the many technical journals which have proliferated over the past few years; personal experience suggests that perhaps eight monthly journals are obligatory

reading, in addition to a number of new books, the rate of publication of which far outstrips that in any of the traditional school subject areas. Yet a further dimension of learning is added by the machines themselves, since familiarisation with the intricacies of a microcomputer such as the Acorn/BBC machine which is much in evidence in United Kingdom schools is in itself a demanding process. Moreover, the microcomputers themselves are not the only machines to be mastered. Peripherals such as disk storage systems, printers, Videotext and Teletext adapters and network interfaces each have their own operating systems, all of which have to be learned. Finally, the software itself represents an additionaal learning burden, especially as it becomes more ambitious; to demonstrate software to colleagues or to teach to students, requires considerable prior time spent in study and evaluation. Comparisons with other, more traditional and static, subject areas are simply not realistic.

20. This is not a problem which is likely to go away. The preparatory training which is undergone by some teachers -- for example, that supplied by the French long courses -- does not obviate the necessity for the co-ordinator-teacher to continue with a constant self-updating. At present, there does not seem to be any evidence of allowance being made for this need. A case-study from one of the Scottish regions (by Mr. C.F. MacLean, Adviser in Educational Computing for Lothian) specifically draws attention to the need to allow teachers discharging these new clusters of functions to have time for the necessary personal development. As matters stand, the demands of computer clubs, peer training and the writing of programs for both pupil use and the use of colleagues (for the motivation to demonstrate to others the values of the new technologies is high) leave time at a premium.

21. But there is in fact a further point to be made, which relates specifically to the needs of the new "NIT-co-ordinator" teachers but which is also of very considerable significance at whatever point, or at whatever level, any teacher comes into contact with the new technologies. It is a point upon which a special emphasis will be placed in this report; namely, that the learning demands imposed upon teachers are not merely of the kind identified above -- centered, that is, upon learning about the technology. Onerous though this area is, there is an even greater learning challenge to be faced which is not technological but essentially pedagogical in nature.

22. The point emerges if we re-examine the list offered above, of the new functions imposed upon the co-ordinator-teachers. Peer training, for example, calls for a high degree of androgogical understanding, to say nothing of associated skills in interpersonal relations and sheer old-fashioned diplomacy; this latter is much called upon in situations, all too frequently encountered, where colleagues (possibly of considerable seniority) are hostile to or suspicious of the new technologies. Resentment of the comparatively lavish resourcing currently available to the NIT in schools and colleges is often another complicating factor; the case study by T.D. Pike refers to this.

23. Similarly, while it is clear that the design of good software calls for an understanding of what computers generally, and a particular machine specifically, is capable of doing, what is also called very much into question is the teacher's ability to construct sound learning experiences. This clearly is a pedagogical, not a technological, skill, and the fact that the teaching/learning medium is new makes all the greater demand upon pedagogical analysis and design.

24. The need for development in these areas is very great. Indeed, if the new technologies are not be, at least misunderstood, and at worst abused in educational terms, it is essential that attention be given to training in these areas. A heavy investment in the further professional development of these teachers is called for.

C. Implications for the Generality of Teachers

25. The relatively clearly discernible set of functions which are emerging for the new NIT teacher-co-ordinators provide a useful introductory basis on which to attempt a similar analysis of functions for the generality of teachers across all subject areas. As we do so, the picture inevitably becomes less clear-cut. It is necessary to recognise, for example, that there are many individual teachers, even in those countries relatively advanced in their uses of the NIT, who remain unaffected by the new developments. The reasons can be diverse: in many cases, there exists suspicion or downright hostility, the basis of which may be anything from personal antipathy to technology per se to a distrust of educational consequences of the NIT. Often, this distrust reaches back to experience of programmed learning experiments, which is one of the more unfortunate associations conjured up by the vision of computer technology in education. Pike, in the United Kingdom paper referred to, mentions this distrust; it is a common phenomenon. For many other teachers, the delay in adjustment may stem from mechanistic factors as simple as non-availability of appropriate software in a given curriculum area.

26. But this is only the negative side of the coin. Equally, there are a great many teachers who are neither teachers of informatics nor responsible for the NIT on an institutional basis who have been working with the new technologies for a sufficient length of time for a preliminary analysis of functions to be made. At this stage, the analysis must be relatively simplistic, and it is certainly open to extensive modification as we improve our shared understanding of what the NIT imply for education. Nonetheless, the analysis can be made; here, it will serve also as a basis for the more prospective view of the next section and for an examination, finally, of the implications for teacher education.

27. In the analytical researches undertaken by the Information Technology and Teacher Education group of the Association for Teacher Education in Europe, it has proved very useful to take as a starting focus the progression from machine-related factors to factors related to the (educational) environment (van Weert 1984). The same starting point is adopted here, though the analysis offered is differently expressed. This orientation to the question of teacher functions produces a three-stage pattern. This will be dealt with in outline first.

28. First, there are functions related to the technology as machine. There are broadly two functions involved here; they are:

-- Basic machine competence; and

-- Competence in management of the hardware resource.

While these might appear at first sight to be relatively low-level functions (as, essentially, they are) they nonetheless represent a formidable addition to the range of competencies hitherto acquired by teachers.

29. Second, there are functions which relate to software -- in other words, to available applications of the NIT. For the present, these may be represented simply as:

-- Competence in the range of applications offered by the NIT.

Nonetheless, this is in itself a very wide field, and the extent to which it broadens the range of teacher functions is, as we shall see, very considerable.

30. Third, there are the classroom-based functions, related to the translation of the potential of the technologies into pedagogic use. This, also, is an extensive and complex field, but for the purposes of outline only it may be identified as:

-- Competence in the pedagogic use of applications of the NIT.

31. Before we proceed to a closer examination of these three broad areas of teacher function, there are one or two general comments which need to be made. One is that the key area, at present, is the second: acquisition of an understanding of what the technologies are capable of doing. Another is that the first two, related the hardware itself, tend all too easily to become disproportionately important. There are reasons why this should be so. Using a microcomputer -- considered purely as machine -- is, after all, considerably more complex than using, say, a slide projector or a tape-recorder in the classroom; the fact of pupil use is in itself sufficient to present the teacher with a host of unforeseen problems. But the reasoning goes deeper. There was a phase in the evolution of the automobile when to be a driver one needed also to be a mechanic (or be able to employ a driver-mechanic); the same was true of the early aviators. Similarly, there has been a period in which the use of the computer has been very much the province of those able to master it as a machine -- in other words, to program. This is reflected in the contents of many syllabuses dealing with what is termed, in the United Kingdom, Computer Studies, and also in the assumptions which many teachers bring with them to in-service training courses. One of the most welcome of recent trends has been a discernible move away from this emphasis on the teacher as programmer, in the direction of teacher as (informed) user. If this shift is to be maintained, it becomes important to see that all teachers understand the range of applications of which the technology is capable. It is competence in this area which stands at the interface between the technology and its educational use; once this is more broadly established than it is at present we shall be better placed to proceed with pedagogical exploration.

32. We may now look in more detail at each of the functions identified above:

a) Basic machine competence

33. The teacher has long been someone who handles, as an aid to the teaching/learning processes, a range of technology which encompasses

recorders, film projectors and slide projectors. Teachers of sciences normally draw upon a wider range, but the majority of teachers operate with a very limited range of technology.

34. Using the microcomputer takes the teacher into a more complex area, and one which is rendered so by the interactive nature of the technology. That is to say, basic machine competence requires not only the ability to switch a machine on and off, or even to load and save programs. The run-of-the-mill techniques of entering data, retrieving crashes, making backup copies, dealing with disk faults, obtaining printouts and screen dumps are all necessary to the teacher who wishes to be no more than a competent client, one who uses the resources of the new technologies without necessarily becoming involved in any developmental work. The addition to the teacher's range of competencies must not be underestimated. There are far too many points at which the technology can "play up", and thereby ruin a carefully prepared lesson (this can and does happen to all of us, however competent we may be) for the matter to be taken lightly -- especially, as we have said, given the interactive nature of the medium. It is often difficult enough for the teacher to deal with his or her own errors, but it is necessary also to be able to cope with child-induced errors. One answer to the problem (though at best partial) would be a considerable increase in provision of ancilliary staff (technicians) competent in computer hardware, but in present economic climates it might be unwise to bank on this being available in the short term. The implication is that there exists a range of basic machine competencies which will be needed of all teacher users of the new technologies.

b) Competence in management of the hardware resource

35. Teachers express concern about another extension of their competencies which is also at a mechanistic level; the extent to which this is a problem depends on the amount of hardware available. The point is that, while fully-equipped computer classrooms are now coming more widely into being, they are still not commonplace. Hamilton and Casserly, for example, in a study prepared for the United States background report, refer to an analysis of the hardware situation in schools associated with the Council of the Great City Schools (and hence not claimed to be wholly representative of the United States). This indicates an average ratio, at secondary level, of one computer (micro or terminal) to every 186 pupils, though ratios ranged from 40:1 to 473:1. At primary level, the average was 863:1, in the range 97:1 to 4 000:1 (!). Clearly, reducing such ratios is a long-term and expensive task: a very crude notional calculation for the United Kingdom, based on projected expenditure for the City of Manchester over a five-year period, and aimed at putting twelve microcomputers into every City secondary school, would cost approximately £85 million. The implications for teachers are obvious, and the statistics illustrate perfectly why teachers who habitually use computers frequently find themselves carrying delicate and fragile equipment around school buildings and elsewhere. There exists, clearly, a major problem of resource management, and there enters a new teacher task: that of working out how best to utilise a form of learning which is heavily machine-based when the number of machines available is not adequate. In an ideal world, the problem would not exist, but it does, and represents a major additional burden upon the teacher; the burden is not the less for being unnecessary.

c) Competence in the range of NIT applications

36. While the new functions identified under (a) and (b) above are certainly demanding, they are nonetheless, as has been made clear, essentially machine-related tasks. But what is true for business users of the new technologies is true also for education, namely that the hardware is of less intrinsic importance than the software which it runs. Thus it is only when we move away from machine-related issues and begin to examine the range of applications offered by software that we can truly begin to explore the educational potential of the NIT.

37. The full range of this potential is only beginning to emerge. Early developments were characterised by two emphases. One, upon uses in the field of mathematics, is understandable given the developmental history of the computer, but misleading insofar as it gives only a very limited picture of what the new technologies have to offer. This problem is doubly confounded by the fact that mathematics, sadly, is a subject area in which many teachers as well as pupils profess limitations and even antipathy. While there are strong, and bi-directional, links between mathematics and computer usage, there are, as we shall see, many more possibilities for educational development than in the field of mathematics alone. The second emphasis, upon relatively simple drill-and-practice programs, is even more unfortunate. It is also wryly ironic, in that the unprecendented but still limited powers of the microcomputer have tempted many teacher enthusiasts into producing such programs, when experts who have worked for many years in the field of Artificial Intelligence, using mainframe computers, realise just how far research and development have yet to go before we can produce programs which begin to match the sophistication which the teacher brings to the instructional function (O'Shea and Self, 1983). We return to the question of Artificial Intelligence later.

38. The emerging picture of educational uses of the NIT is much broader. To a considerable extent, it draws upon developments in the field of business applications, where the incentives for progress have been high. And because the picture is a broad one, it is essential at this point that we introduce a second level of analysis, which will offer a perspective on this central question. It is possible to identify the following (not necessarily complete) range of applications.

Drill and practice

Although it is unfortunate that applications of this type have tended to be more in evidence than is ideally desirable, it would be pointless to overlook the contribution which drill and practice routines can offer. They offer a considerable potential for reinforcement of learning, and an opportunity for some pupils to progress to challenges at an appropriate level without necessarily waiting for the teacher to intervene. What is perhaps even more useful is to see drill and practice in a developmental context: with the technology available in sufficient quantity in any one school, and with appropriate software also available, drill and practice can lead easily into computer monitoring of performance and thence into fully-fledged computer-aided student profiling and management of learning. This possibility raises, of course, a number of educational questions -- for example, there is the danger of monitoring student performance solely in terms of assessments which can in fact be made by compters; Section d) below will take up pedagogic issues of this nature;

Electronic blackboard

The technologies offer the teacher an electronic "blackboard" of a kind not hitherto available, and which represents an important addition to the teacher's repertoire. Its significance as a teaching aid is two-fold. First, it is dynamic, in that it can change rapidly, in time, as a schematic representation of information; this is a quality which it posesses to a greater degree by far than, say, the slide or transparency projectors. Secondly, it is interactive with the input of either teacher or pupil, and this creates a flexibility which is simply not accessible, or only in the crudest form, via existing technologies. This, clearly , is an important facility. Nor should it be seen as relating to work with numeric data only: the word-processing software with which this paper is being prepared, for example can also be used as an electronic blackboard (as can a beautiful and inexpensive primary wordprocessor which recently became available in the United Kingdom).

Games

Computer games, of the kinds available in arcades and for home computers, have been much criticised for the hold which they exert on young minds. Yet, as M. Jean Valérien points out in his study of NIT developments in the Britanny region of France, the electronic microworld of the game is an important part of the adolescent's reality, and cognisance must be taken of the fact. Games succeed or fail on the challenge which they offer to the player's skills, and there is here a potential which very much calls out to be used in education. This is beginning to happen, and already adventure games exist on the educational market which offer a strong stimulus to both the imagination (some of the most interesting are aimed at primary level) and the development of problem-solving skills. It is likely that current developments in linking video imagery to the computer (see Chapter III below) will further increase the attraction and potential of games.

Simulations

While the distinction between games and simulations is of course important -- games belong in the world of fiction and fantasy, or else are "play" presentations of problems, while simulations model a part of the real world -- it is clear that they offer a similar attraction. The computer-based simulation offers a potential for examining a very wide range of situations which it would not normally be possible to examine in the classroom (for reasons of size, complexity or risk element) and it does so in a way which is, once again, dynamic and interactive. Here again, the marriage of video imagery with computer programs and computer-based data banks must inevitably contribute to the impact of simulations, and it is possible that this will prove to be one of the most important growth areas in the development of computer-based learning.

The representation of knowledge

Here also there exists a very great potential indeed for the educational application of information technology. Indeed, it is at this point that the very close links between the NIT as a phenomenon, on the one hand, and on the other the process of educating, become most evident. Both are concerned with facilitating our ability to transmute raw data into knowledge -- i.e. data which has been structured, organised, above all understood by the user -- and which can be recalled, and if necessary re-structured and re-interpreted to meet fresh demands. (In at least one European language -- albeit a minority language, Welsh -- the term "Information Technology" is rendered as "Knowledge Technology".) If we are to deal succinctly with what is a large and complex topic, it may be helpful again to refer to uses of the NIT in the field of business. There, it has become the accepted target for "integrated" software that it shall provide within the one shell facilities for data processing, for text processing, for numeric calculation (spreadsheet) and for the graphic representation of number and quantity. Each of these separately offers a direct aid to the teacher and to the learner; integrated into the one package, as in existing business software, they will offer yet another dynamic resource for the teaching/learning process. (It is correct to say "will" rather than "would" offer, since it is already possible to use business oriented software for educational purposes; this remark is based upon experience of using, for example, business data base and spreadsheet software in the training of primary teachers.)

The formal construction of knowledge

One of the most prolonged debates in computer-based education has concerned the practice of teaching pupils the skills of programming. Much of this debate has centered around the alleged unsuitability, for educational purposes, of the language most used in the English speaking world, namely BASIC. Certainly it is true that BASIC is a conceptually untidy language, and it is also highly debatable whether all pupils and all teachers need to be skilled at programming. However, one has to recognise also that languages whch have appeared more recently, of which the best-known are LOGO and PROLOG, put into the child's hands what Seymour Papert likes to call "powerful tools" with which to engage in the formal exploration and construction of knowledge. This is an important concept, which needs careful attention (Papert, 1980).

39. Clearly, it would be possible to enter into a great deal more detail in respect of each and every one of the applications of the new technologies listed in the last paragraph. Equally, it would be possible to add one or two more categories to the list as it stands. But the point is not to establish a definitive categorisation; in such a rapidly evolving area, such an attempt would be shortlived. What is more important is to establish that there does exist a wide range of applications of the NIT, such as the range described here, and that these applications all bear, in their different ways, upon the possibilities open to the teacher in the classroom.

40. If these possibilities are to be realised, however, then teachers must be more than simply knowledgeable about the range of applications available. The new technologies further demand that teachers have a grasp of their pedagogic implications.

d) Competence in the pedagogic use of the NIT

41. We saw under Section (c) above that there exists a wide range of possible applications of the NIT in the classroom. Their existence raises the question of their implications for, and their impact upon, the ways in which we teach and in which our pupils learn.

42. This impact varies according to the nature of the application in question. For example, if we are thinking of "electronic blackboard" applications, then, though these may make new demands upon the teacher-user, they need involve no re-think of the pedagogy in operation; the gain may be considerable, in respect of, for example, the dynamic quality which may be given to illustration, and pupils' learning may be much facilitated, without there being any fundamental change in the teaching/learning styles involved. But from there on, it is difficult to conceive of the new technology's being used without pedagogical practice being called into question.

43. The point emerges even when elementary drill-and-practice routines are being used. When the child is operating a program of this kind at the computer keyboard, the learning (or learning-reinforcement) situation is quite different from that which operates ordinarily in the classroom. To begin with, the pupil's situation is private, so that mistakes made do not risk public comment (or ridicule) from either fellow-pupils or teacher. Secondly, there need be no element of competition. In any classroom where questions are asked publicly, there are, inevitably, those pupils who are prompt and eager with their answers, and those who are more reluctant and/or less able. It is a situation where, with the best will in the world, it is difficult to prevent many children from acquiring negative self-images vis-a-vis their contemporaries, with a feed-back effect upon further learning which is well-known. In the private dialogue with the computer, however, the pupil need not be hurried by any implicit competitiveness: it simply does not exist. In its stead, there emerges a challenge to the pupil as an individual, a challenge, moreover, which good programming can render appropriate to the pupil's level of attainment. Given, additionally, the capacity of this kind of CAL to monitor the pupil's progress and to log for the teacher the number of errors made, and the levels at which they occurred, it becomes clear that there is now available to the teacher an additional teaching strategy which has not hitherto existed. The deployment of this resource (quite apart from the mechanics of sharing it across the class) becomes a pedagogic question of considerable interest (Bossuet, 1982).

44. What is being invoked, of course, is an extension of our present potential for the individualisation of learning. To say this is not to suggest that individualisation is an over-riding goal; there are many cases where it is inappropriate. But it is equally, and importantly, true that there are many occasions where it is supportive to tailor the learning experience as closely as possible to the developmental needs of the individual, and it is already clear that the computer, not to mention other aspects of the NIT, has a great deal to offer in this respect.

45. But once we begin to explore the pedagogical implications of NIT applications, we find ourselves moving into increasingly interesting levels of enquiry. In the last two paragraphs we have identified one or two of the positive features of the pupil-computer interaction -- the relative privacy of the situation, the removal of competitiveness. But these are not the only

features of the situation. Whether the software involved be drill, game or simulation, whether pupils work at the keyboard individually or in groups (both styles, of course, are appropriate at different times) it is clear that working with computer-based programs offer children a learning experience which is different from others normally available in the classroom. Many factors come into play: the fact that the computer does not appear impatient, that it can respond instantly and accurately to whatever is input to it, that it appears objective and neutral in its responses (all sorts of subjective remarks, of course, can be written into programs, but that is a different matters) and that, perhaps, the mere fact of its being a machine -- all of these, and other factors as well, make up a learning transaction which is somehow different from that to which we are accustomed in the classroom. Precisely what the nature of that transaction is, it is too early to say, and it is an area where a considerable amount of psycho-pedagogical research is called for (O'Shea and Self 1983). What is clear is that the new element which it introduces calls for an extension of the teacher's pedagogical armoury.

46. The point need not be laboured, but it is important to point out that it increases in significance the more we consider the range of applications available. The introduction of data bases, spreadsheets and word-processing, for example, are all of the utmost importance for the functions discharged by the teacher. What is critical here is the extraordinarily close match between the process of acquiring learning, on the one hand, and the nature of the new technologies on the other. To acquire learning is to develop the ability to retain a mass of raw information, and to structure and shape it in such a way that it becomes useful knowledge or understanding that can be called upon, applied to different situations and conveyed to others as necessary. And this, of course, is precisely what the new technology has been created to do: to capture data, process, structure, retain, recall and transmit. The conceptual overlap is remarkable, and it would seem essential that all teachers acquire an understanding of the ways in which computer applications such as data bases and wordprocessing offer their pupils learning tools of a new, and extremely important, kind.

37. There is a similar point to be made about the computing languages increasingly becoming available to education. Within computer education circles, there is an on-going and fierce debate over what many see as the unsuitability of the language most commonly used for education in the English-speaking world, namely BASIC. It is certainly true that there appears little intrinsic worth in teaching BASIC outside of the Computer Studies syllabus. Other high-level languages, notably PASCAL and COMAL (Atherton, 1982) offer intellectual challenges which have more intrinsic worth, but their place still lies within the subject area. However, the same cannot be said of LOGO, which is best known for its Turtle Graphics capacity (though this is only a subset of a full LOGO) and for its accessibility to even very young children (Bossuet, 1982; Papert, 1980; Watt, 1980, 1983) or of the more recent PROLOG, through which lower-secondary children can create and interrogate quite complex data-structures (Ennals, 1983; Clark & McCabe, 1984). Languages such as these move outside the computer studies area -- though they are based on the soundest of computing practices -- and begin to be relevant to a wider range of subject areas, further extending the pedagogic repertoire available to the teacher. Whereas the applications referred to in the last paragraph are invaluable in the organising of knowledge, these languages make an equally important contribution to the

building of concepts. PROLOG, for example, or its microcomputer version micro-PROLOG, offers insights into logical relation setting which is as much the province of the teacher of the mother tongue or of History or Geography as of Computer Studies.

48. The catalogue of possibilities presented here is by no means exhaustive, and there can be no doubt that others will emerge. But the prospective analysis is the subject of the next chapter; what is important to emphasize here is that everything which has been said has been based on developments, at the technology/software end, which have taken place already.

49. This last is a sobering thought, for if all the hardware and software developments on which the foregoing paragraphs are based are already with us, it is far from being the case that we have learned to make full educational use of them. All that we can say at present is that it has become possible to reach the stage at which a paper such as this becomes possible -- that is to say, one which offers, with reasonable confidence, an analysis of the issues at stake. It would be sensible to assume, in all probability, that it would take at least another 20 years to learn to exploit even these developments to the full; given the inherent conservatism of the education system (though not of teachers) 20 years is perhaps a wildly optimistic hope.

50. But at least the analysis is possible. It becomes possible, on present knowledge alone, to see how teacher functions are already open to modification. And from this analysis one point emerges, the importance of which cannot be over-emphasized. It is that the changes which we can identify in the teacher function are not themselves intrinsically technological in character: they are, as we have seen in the case of the NIT co-ordinators, pedagogical in nature.

51. If we take a broader view, this ceases to be surprising. While the invention of the steam piston engine was important as a technological advance, it was less important as technology *per se* than as the invention which made possible the railway engine, which in turn made possible the movement of coal, raw material and goods, the transport of human beings (Lenin, for example, to the Finland Station) and the production and distribution of cheap national daily papers. The technology has been important only for what it makes possible -- in the case of the steam piston engine, massive social, economic and political change.

52. When this perspective is applied to the NIT in education, the full complexity of the situation faced by educators in the last decades of the twentieth century becomes, if possible, even more apparent, and it is at this point that it becomes important to concentrate on issues which are capable of being confronted in practical terms. For there are, in fact, two major considerations implicit in the wider perspective. We may take first the larger of the two, which is in fact analogous with what has just been said about the steam engine. It would be irresponsible of educational planning to ignore the predictions currently being made (Toffler, 1980; Stonier, 1983 -- to select but two out of many texts) about the impact of the new technologies on the social and economic structures of life in the 21st century. If these predictions are only in part fulfilled -- which seems inevitable -- then the societal context in which education is situated will have been altered to such an extent that our systems of education will have themselves to change.

53. But this, as we have said, is the larger of the two considerations subsumed under the broad perspective on technological development, and as such it more properly relates to the prospective analysis of the next chapter. The more specific consideration is in no sense prospective: it is the point made above, that the implications for education of the technology as we already know it are extensive to a degree in the re-think they demand of the functions of teachers, and that such a re-think needs to focus far less on the technology per se than upon the pedagogical developments which it makes possible -- which, indeed, it makes inevitable. While no-one (surely?) would argue that all teachers need to learn Assembler, it is already difficult to conceive that coming generations of teachers will be able to function without an understanding of the nature of relational data bases and ability to incorporate the use of such resources into their classroom practice. This is a pedagogical issue of the first importance.

54. It would be foolish to claim that the analyses offered in this Chapter -- whether the basic three part analysis of competencies or the more detailed analyses offered under the second and third of these heads -- are definitive. Indeed, given the rapidly evolving nature of the subject-matter, and the rather less rapid evolution of our understanding of it, the contrary is to be hoped. The important point is that the analysis can at least be made, that it can be made on the basis of what we know already of the NIT and their impact upon education, and that it leads us already to an understanding of at least the likely pattern of change in teacher functions. On this basis, we can begin to look at the steps needed to set in motion a better-planned transition to the necessary pedagogical changes, through teacher training especially. This will be the focus of the last Chapter of the present paper; before coming to the question of teacher training, however, we need also to incorporate into the overall picture the more prospective analysis of the next chapter. While this, too, is firmly rooted in reality, in that it is based on technological developments which either have taken place already or are confidently predictable on the basis of the existing, it does nonetheless open up issues which have not yet been touched upon, in any real sense, in educational planning. Such issues are a necessary complement to those identified in the paragraphs above.

Chapter II

CHANGES IN TEACHER FUNCTION: THE PROSPECTIVE ANALYSIS

55. In the light of our expressed belief that it will take twenty years at least to extract full pedagogical capital out of the technological resources at present available to us, it may seem surperfluous to engage also with "what-if" analysis. Future predictions are notoriously difficult, and we should also take into account the fact that some of the existing teacher mistrust of the new information technologies relates to predictions that teachers, like other classes of employee, will be rendered redundant by the new technologies. Such a mistrust, we may add, is not confined to teachers along: there is a wide-spread repugnance, amongst parents and many others, for the notion that Artificial Intelligence machines of the future might be entrusted with what has always been the human relationship of teacher and pupil.

56. This particular bogey is clearly germane to the debate, and we shall return to it. However, a prospective analysis of likely developments of the NIT in education does not have to extend as far as the possible teaching computers of the next century. It is not even necessary to base such an analysis on any technological "what-if". We have seen already that there is a great deal to be done to exploit the new technologies which have already entered educational practice; there is even more to be done to respond to those technological developments which have already taken place but which have not yet affected education. (This last point is relative, since some of the developments in question are on a continuum from other already referred to, but there are, nonetheless, important distinctions to be drawn.) In the remainder of this report we shall be concerned only with technological advances which have already taken place or with relatively limited extrapolations from these into the near future; we are emphatically not concerned with predictions based on science fiction or fantasy.

A. Five Areas of Technological Development

57. It will be helpful, first, merely to identify a few areas where technological development has a particular relevance to education:

i) We are already witnessing a rapid increase in the processing power of the microprocessors used in computers of the kind found in schools and homes. The first microcomputers to become widely available in schools were eight-bit machines; 32-bit processors are already in machines being marketed, with all the increases in processing power and internal memory that 32-bits imply (Mateosian 1984). The processing power of the microcomputers which will be available cheaply in, say, four years' time (1988) will bear no comparison to the power available to the machines produced four years ago (1981).

ii) Equally significant are the advances constantly being made in backing storage; indeed, the rapid reduction in the cost of memory per byte is regarded as one of the most important developments in microcomputing technology. Two areas are of interest here: one is laser disk technology (Duke, 1983; Rothchild, 1983) while the other is the techniques being developed for dense encoding of electronic data (Johnson, 1983). Both methods make for a vast increase in the amount of information which can be easily stored and made cheaply transportable.

iii) The growth in storage capacity is closely linked to another advance and indeed makes it possible; this is the capacity to create multi-media resources. The OECD/CERI paper prepared by Professors Le Corre and Schwartz is especially valuable for its comments in this area (CERI/NT/83.07), and we note their prediction that laser disk storage capacities will increase tenfold within the decade. Since these disks can already encode data of different types (Le Corre and Schwartz quote, for example, five million pages of text or one hour of live video) the potential for multi-media storage is extremely high. This development is of extreme interest for the creation of educational resources.

iv) Developments in software are also of interest. While the evidence is that attainment on a microcomputer of the integrated, multi-function software which business normally expects of a mainframe or a minicomputer is still elusive, rapid strides continue to be made and are supported by the emergence of the 32-bit processors and increased memory (Brown, 1983; Callegari and O'Connor, 1983; Chang, 1983). The emulation of such packages at the level of the school will be of considerable significance. Other software developments of high interest include a recent breed of programs in the United Kingdom and the United States which are marketed as "thought-processors", i.e. electronic notepads which, through the use of tree structures, can identify correspondences between different sections of, for example, notes used in the preparation of research reports. The educational potential of both these developments is evident.

v) Fifth, account needs to be taken of the high state of development reached in communications technology. Hitherto, the focus of thinking about the NIT in education has tended to be exclusively the microcomputer itself. This is a point heavily emphasised in the OECD paper CERI/NT/83.11. Only now, with the advent of telesoftware (still in a rudimentary state) and early steps towards the educational use of Videotext are we beginning to explore this potential. Both fibre optic cable relay systems at local levels and developments such as direct broadcasting by satellite at international level open up new dimensions in the delivery system possible for educational materials (Maddison, 1983).

58. We have here identified five fields in which development is proceeding apace, where it is not necessary to engage in long-term speculation, and where there are clear implications for educational use. We shall turn in a moment to analysis of some such possible uses, and attempt to see what a scenario for the development of teacher functions over the next decade might be. First, however, there is one other area of which mention must be made.

B. The Contribution of Artificial Intelligence Research

59. While the field of Artificial Intelligence is one much mistrusted, and probably misunderstood, from the outside by teachers and others, it is important to note that it is also the field in which the most serious research into the NIT/education interaction has been going on the longest. Indeed, if we pay due attention to the "new" in NIT as relating essentially to the era of the microprocessor, then we have to recognise that AI research in education predates the new technologies, being based as it has been on university mainframe computers. It could well be the view of the researcher in AI that the easy accessibility of microcomputing has been a hindrance, rather than a help to progress, since it has given a seemingly seductive computing power into the hands of amateurs who are not qualified to use it and who do not realise that, marvellous invention though it is, the microcomputer as we have so far known it does not have, in fact, the kind of power required on which to create interactive expert systems. Certainly, many of the so-called CAL programs which exist at present are crude, miniscule and trivial compared with programs developed on mainframes over a decade ago (O'Shea and Self, 1983).

60. The question which popularly arises in question with AI in education, one upon which we have already touched, is that of the possibility of constructing expert tutor systems, capable of dialoguing with students and, in effect, of supplying the teaching function. If this proves to be possible, then clearly there are major repercussions for the world of education, since the role of the human teacher is itself called into question.

61. A full treatment of this issue would require a greater space than is available here, as well as a more expert writer. But the consensus currently appears to be that, while it is in theory possible to construct such systems, in practice the sophistication of programming required remains elusive. O'Shea and Self, in the work cited, and Boden (1977) point to the very long way that still has to be travelled in the direction of the expert tutor system, despite the achievements of, for example, the PLATO system in the United States. Thus the spectre of the teaching force being replaced by computer terminals is perhaps remote -- so far as AI is concerned: there is a greater threat to the teacher, to which we shall return.

62. But the production of a computer-based tutor system is not of course the only goal of AI research. It is far more profitable, for the immediate

future, to look to AI for continuing insights into the ways in which computers can be made to model learning processes, and for the psychological insights which such research can bring. It is important to recall, for example, that the widely-acclaimed LOGO, to which reference has been made more than once in this report, is itself the product of research into Artificial Intelligence.

63. Equally interesting to education is the work currently being done by Artificial Intelligence research in respect of "expert systems": that is to say, extended data bases into which are fed the knowledge and the rules called upon by human experts in addressing decision making in given areas, the system being programmed to extract "inferential" conclusions from the data supplied. The best known such system already operative is in the field of medicine. While expert systems are still at a relatively early stage of development, they nonetheless exist, they are on a clear continuum from ordinary data bases, and are a means of organising and representing knowledge which has to be of interest to education.

64. It is in areas such as these, rather than in respect of any immediate threat from robot "teachers", that Artificial Intelligence promises to make a highly important contribution to the impact of the NIT upon the teacher function. What could well be strengthened is the interface between the world of research and the world of the classroom and of teacher training -- the latter perhaps especially. Excellent models for such interaction exist -- as for example between the MIT LOGO Project and schools and at the University of Edinburgh, and it would seem essential that the interaction be extended.

C. The Pedagogic Implications

65. For the present, it is possible to construct the necessary prospective analysis of further changes in teacher functions by examining more closely the technological developments identified in section A of this chapter (para. 57). A number of inferences can be drawn: there are perhaps four of these.

Resources

66. The first is that there exist already the technical means for organising learning resources in ways which have not hitherto been possible. Le Corre and Schwartz draw important attention to this possibility in their paper, and this report echoes their identification of "interactive multi-media computerised learning environments" as a key to progress. Where one might wish to draw somewhat different conclusions is over their prediction of the kind of use which might be made of such resources. There does not appear to be any particular reason why the multi-media packages envisaged should be seen as instructional in function -- indeed, the reverse. To attempt to use such technologies for instruction will be to encounter afresh all the difficulties referred to above in respect of tutoring systems. Instead, it would seem more appropriate, at an early stage of development especially, to see multi-media technologies as not being electronic only, and also to see them, above all, as resources. Whatever data, sound, still or video imagery is encoded on an education-oriented video disk could and should be linked to other media at

least in the first instance -- certainly until the NIT offer clear advantages over the portability and readability of worksheets and books. The essential, it would seem, in the development of these new packages, is that the overall function of the teacher be enhanced and not diminished. The specific new task created for the teacher will be that of mastering and using this enormous potential, and this will be a major challenge. But if teachers are involved with the task of authoring the new resources, two benefits will accrue. First, use of the NIT will be able to draw upon the limitless experience which the teaching profession has accumulated over many generations. Secondly, the teaching force itself will be engaging with the NIT in a positive manner which will serve as a further focus for professional development. [The case for seeing the new technologies as encompassing a number of existing media, and allowing them to be used far more powerfully and creatively than at present, is passionately argued by Maddison (1983)]. For the teaching profession not to be engaged with the production of the new resources could well be disastrous, as we shall see later.

Learning

67. A second inference to be drawn is more challenging. Already we have seen, in the case of LOGO at primary level, that the NIT offer new ways of learning. And there is evidence from the LOGO experience that many teachers find it difficult to adjust to the extent to which LOGO gives the child a considerable element of control over its learning progress. The same is true of the use of PROLOG and indeed of any situation in which the child has use of a powerful computational tool, particularly when the pupil's access to that tool is outside of the control of the teacher -- in, for example, the home. Increases in microcomputer power and in access to large data banks and to privatised learning resources will further accelerate this trend. Thus the new function for the teacher is two-fold: that of adapting to new ways of learning and to the fact of no longer being in control of the learning process. (This, of course, is not really a new phenomenon, since what we know about informal learning tells us that teacher control of the "real" learning process is a myth. What the NIT do is to make the fact more difficult to ignore.)

Knowledge

68. A third point, closely allied to the last but separate from it, is that advances in the NIT already call in question our existing definitions of knowledge. Laser-encoded disks can carry the equivalent of five million pages of text. But, protected as they are by plastic film, laser disks are far less sensitive than are current floppies or Winchesters; they can, for example, be stacked and "played", juke-box fashion ... ten laser disks -- even one laser disk -- will carry far more information than any one individual will need to access in a lifetime. Similarly, the current advances in storage offer portability. Memory cards (plastic cards encoded with data either elecronically or by laser) are already on the market (Johnson, 1983; Mills, 1984; Rothchild, 1983) and mean that the individual could carry about, in a small wallet, all the information that is likely, for example, to be required during the working week. This is to say that knowledge per se carries a far lower premium. What is more important to develop, and what represents a major new extension to the teaching function, is the ability to

access knowledge and to use it when found. As we saw in Chapter II, the growth of data banks already calls for teaching responses; what the new encoding techniques do is to exaggerate the demand even further. This is perhaps one of the most exciting challenges for education in the context of the new technologies. What is also interesting is that it demonstrates how the NIT can actually have a liberalising influence on education, in the sense that its use leads to an emphasis on the development of understanding and on the use of knowledge, at the expense of rote learning.

Communications

69. The final prospective inference to be drawn from existing technological developments is in many ways the most open-ended and the most contentious. We have noted already that there is more to the new technologies than computers alone, and that, for example, the communications aspects have important implications for education. In effect, existing communications capabilities are sufficient to raise a question mark -- in purely technological terms -- against the existence of school as we know it. Distance learning, after all, is far from new in a number of countries, and the NIT technically offer a fascinating opportunity to go beyond anything yet achieved in the delivery of learning. This is certainly likely to happen for learners in remote communities, in hospitals or who are house-bound. The question arises over the extent to which such developments should be allowed to affect what we now regard as compulsory schooling. School itself is a delivery system for learning, and it is at least debatable that the new technologies offer a more efficient delivery service -- and very likely one that is more economical. Le Corre and Schwartz see this ("... education will become less dependent on the centralised school setting."). Stonier (1983) argues interestingly that:

> "The major shift in technology... involves the emergence of the electronic home-based education capability using the television screen and the computer terminal as its base, tied via telephone, airwaves or local cable television to the local education authorities, a second tie-in to national and international computer networks and finally a tie-in to the global library archives."

It is difficult to avoid the conclusion that there is some substance for this prediction (Gwyn 1982), however difficult it may also be to see Stonier's prediction as spelling the death of school. School has evolved over a very long period of time, and fulfills a wide range of functions. These include, very importantly, the socialising function and, at a lower level, the custodial. The vision of children below the age of ten receiving their education via their own home terminal or that of a neighbour is, essentially, the middle-class vision of the pre-school playgroup which may well not correspond to the realities of many parents' working lives. Nonetheless, the NIT Place a very firm question mark against the nature of school as we know it.

70. Nonetheless, the potential of the NIT for the delivery of education is not one to be dismissed lightly. If the totality of present technologies, coupled with those developments which are identifiably imminent, do present the opportunity, as we have seen, to produce new multi-media teaching resources, we have also to recognise that the processes of production will be expensive. Collaborative, studio-based teams are likely to be required. Such a development must be viewed positively if it means an end to the small-scale,

educationally inept software with which we are currently encumbered, but there is the negative effect that the production process becomes remote from the teacher; this is the threat to which we alluded earlier. Teachers do not normally write their own resource materials -- i.e. books -- at present, but a book-based technology still allows the classroom teacher a very great deal of control over its use. The same is not true of existing educational television; typically, the teacher does not interrupt a television broadcast, and not only for the obvious reason that the broadcast is a one-off: it is also important that television as a medium engages the watcher's attention on a greater scale than does the book. The same will be true of NIT-based resources generally. They are likely to exert a much more powerful hold on pupils' attention than does the book or, by extension, the teacher. Unless teachers have the possibility to be involved in the preparation of the new resources, there is a real danger that they will see the NIT as intruding, powerfully, in their traditional relationship with their pupils. Much will depend, as we have seen, on the extent to which the new software is resource-oriented, and the extent to which it sets out to "teach". The former, we have argued, is to be preferred, especially as a first stage of development.

71. The impact, for the functions of the teacher, of the possible development of the NIT as delivery system for education is intriguingly difficult to predict. The vision propounded by Stonier, presumably, sees no place for the schoolteacher as such, at least not until the secondary stage is reached. But if we believe that the social pressures for the preservation of the school will persist, then a very interesting scenario opens up, in which the teacher has access, through the NIT, to an extensive storehouse of resources, far easier of integrated use than are the educational film and television programs of today -- and far more under the teacher's control, if the prescriptive approach is avoided. The availability of such resources, with all that they imply for the individualisation of learning, will reinforce the influence of data bases and related developments in the liberalising process. It becomes possible to envisage a school in which far more time can be devoted to the growth of interpersonal skills and to creative and artistic endeavour than to learning as narrowly defined. That such a scenario might result from purely technological development would be ironic, but it is a scenario well within the capacities of the technology as it exists to deliver to the schools of the 1990s.

72. Consideration of issues such as these move us increasingly into the realms of the speculative. It is important, however, that we recognise just what is speculative and what is not about the prospective analysis offered here. There are three areas to be taken into consideration.

73. The first of the three may be disposed of briefly, since the point has been made already in this analysis. It is that the technological picture painted here is in no sense speculative. As we have remarked, Chapter II of this paper refers only to developments to which the educational system is already responding, however inadequately, while Chapter III is based only on developments which have taken place or are imminent, but which have not found their way into education. The second and third areas to be considered, however, are speculative in nature.

74. What has emerged from the analysis of Chapter II, and is equally evident from that of Chapter III, is that the responses which the NIT demand

of the teacher role are pedagogic, rather than technical, in their nature. But we have offered already the opinion that the technological developments we have witnessed already would keep us occupied in devising educational strategies to utilise them to the full, to at least the turn of the century. And it is here that a note of caution becomes essential. The potential changes to which we are referring are considerable. In some cases, they call for a radical re-appraisal of our attitudes to learning, to our concept of knowledge and of what it is to be an educated person. In other cases, especially those highlighted in the present chapter, they call in question our thinking about the relationship between teacher and taught, about the organisation of the school and about its function in society. Such questions are not lightweight. We have no means of predicting whether our educational structures, or the social structures of which they form an integral part, have the innate flexibility to enable them to adapt to the many possibilities offered up by the NIT. Most specifically, it seems reasonable to ask whether we have yet an adequate understanding of the processes of teaching and learning to enable us to exploit the new potential to the full. If the change from Industrial to post-Industrial society is anything like as extensive as the change from Agrarian Society to Industrial, and if, as we have to expect, it proves to be concentrated into a relatively very brief time span, then there is reason to fear that our pedagogical wit may be found wanting. The question is, it must be emphasized, speculative, but to ignore it would be irresponsible.

75. The third area to be considered, and the second which we must identify as speculative, has been identified tentatively already, in Chapter I of this paper. It concerns the political will to support educational development relative to the NIT. Such support, clearly, is and will continue to be expensive for the foreseeable future. It seems reasonable to anticipate that, the more such investment becomes investment in education for its own sake, unrelated to economic growth, and the more it is seen to call in question some of the social functionalism that is built into our education systems, the less will be its attractiveness as an area for heavy investment by governments. This is an hypothesis only, and one which, as an educator, one would wish to see disproved. However, in so far as the question is legitimate, then so far must further development remain, ultimately, also open to speculation.

76. We are here, very deliberately, limiting discussion of the kind of social changes which we may be facing, and taking the school itself as the point of focus. But it would be unwise to ignore altogether the extent of possible changes predicted by many as we move from Industrial to post-Industrial society. Such predictions are in themselves manifold; they embrace possible changes in the work-ethic, in the distribution of time between work and leisure, and in the nature of work available, challenges to the privacy of the individual in the face of unprecedented means of control, and questions of the policing that will be required in the "leisured" society. Such questions, clearly, are of the utmost importance for the future of society as we know it, as are the more immediately threatening issues of survival in the nuclear age. The outcome of each and every one of these questions has, clearly, implications, for education systems, for schools, for teachers and for their pupils. That they have not been raised in detail or considered at length in this paper is not an indication that they are considered to be of little or no interest. On the contrary: they are of the greatest moment. The problem which they present is that they suggest degrees of change so great as to be, radically, changes in kind from what is at

present known. A paper such as this can be written only from the tacit assumption that educational development can take place, and will take place, under relatively controlled conditions in which there will be world enough and time for plans to be made, and decisions taken, in a responsible and thoughtful manner. Whether this will, in fact, prove to be the case is in itself a matter for very considerable speculation.

Chapter III

THE IMPLICATIONS FOR TEACHER TRAINING

77. In the previous two chapters we have identified a range of changes in teacher functions posited by the NIT, and have defined these in terms of the new approaches to teaching and learning which the new technologies open up. It is clear that the introduction of these new functions -- whether according to the categories identified here or any other analysis -- calls for a major input from teacher training. It is particularly encouraging to note the seemingly universal acceptance of this principle. The background report on France prepared by M. Jean Valérien relates in detail the teacher training provision made in one French Académie in respect of the new technologies, but the basic principle is widely shared.

78. It is also clear that the effort required is called for at both the levels of pre- and in-service teacher training. This said, all the evidence in background reports from the United States, France and the United Kingdom points to an emphasis on the in-service activity as a priority. This is entirely understandable, since it is an accepted fact that new thinking can be injected into teaching more quickly via this route -- where courses can be mounted at relatively short notice and can be brief and intensive -- than via the necessarily longer pre-service route which produces, after all, the junior members of the profession. Nonetheless, there is evidence also of considerable development taking place at pre-service level; this is found also in M. Valérien's report, in, for example, an extremely interesting contribution to the United Kingdom report by Mr. R. Hartley, Director of the Computer-based Learning Unit of the University of Leeds, and in other contributions.

79. What is evident, however, from a reading of these and other papers, and from discussions within the Information Technology Group of the Association for Teacher Education in Europe, as well as from extensive personal experience of planning NIT courses at both pre- and in-service levels in a large teacher education institution, is that there are major problems to be tackled in this area if we are to have any hope of mounting, via teacher education, a worthwhile response to the challenges faced. This chapter will attempt to analyse these problems and to offer a perspective upon possible action.

80. A first problem concerns the analysis itself. The situation which it examines is essentially circular, with no easy and obvious point of entry to the range of problems to be identified. What seems most appropriate, therefore, is to sketch in, relatively briefly, the entire range of issues before attempting to impose upon it a sense of priorities.

A. INSET - logistics

81. We have seen, in Chapters II and III, that the new technologies carry implications for all subject areas across the curriculum, and that this is true at both primary and secondary levels. Given that the number of teachers at these levels who can reasonably claim to have received undergraduate training in Informatics (even if this were necessarily the best preparation for using the NIT in teaching, which is by no means self-evident) is negligible, what this means is that we face the need to train, as rapidly as possible, the entirety of the teaching profession to use the new technologies. Given the rapid evolution of the whole area, it is scarcely any exaggeration to say that the whole profession needs, by some means or another, to be placed in semi-permanent re-training. There are many reasons why it would be wildly impracticable to think in these terms: a lack of trained trainers, economic constraints, a lack of sufficiently clear agreement on the directions to be followed. The logistics of such an exercise would be overwhelming. And yet this is, in fact, fundamentally the task facing the various agencies of teacher in-service training, and its seriousness should not be ignored.

82. So far, the most visible scheme to have emerged at national level is that of France, and it is clear to anyone who has studied the French programme that there is a great deal to be learned from the scheme. The MEP scheme in the United Kingdom also places a heavy emphasis on teacher training (vide the United Kingdom national report by former HM Inspector Maurice Edmondson) but, in the nature of the United Kingdom decentralised system, is not in a position itself to offer INSET schemes on the same scale.

B. Pre-service: Structures and Resources

83. As we have said there exists a greater possibility of flexible responses to new developments at in-service level than at pre-service. In the latter area, courses are of longer duration and often subject to formal processes of approval and control which are less easy to change. Frequently also, pre-service courses for intending teachers are intensive in their pressure upon the students' programmes; Maurice Edmondson remarks on the difficulty of inserting new areas of learning into already crowded curricula. (This is a problem which mirrors the debate in France over the insertion, into the secondary curriculum, of Informatics as a discipline; if this is to happen, something else has to give way.) Personal experience has demonstrated how difficult it can be to insert into the very crowded one-year course of post-graduate teacher training in the United Kingdom anything approaching a sufficient initiation into the new technologies for all students -- and this in an institution where colleagues are strongly supportive and hardware resources available. What is equally interesting, in the same context of personal experience, is the marked increase in student demand, over some three or four years, for some element of computer literacy to be introduced into their courses.

elsewhere -- and this is subjective testimony but borne out by colleagues from a number of countries -- the heavy demand for training in respect of information technologies and education leaves those able to offer the training required with very little time indeed for research. This problem in fact extends beyond research; it is common to hear colleagues who train in the uses of the new technologies complain that their commitment to the professional development of others leaves little or no time for their own. We have touched upon this problem already in examining (Chapter II) the role of, and the demands upon, the new "NIT co-ordinators" in the schools (C.F. MacLean, Lothian Case Study for United Kingdom Background Report). It is a relatively new phenomenon, as of course is the whole area, but it appears to be already a serious problem for teacher education.

D. The Need for Policy Guidelines

88. A final problem area concerns the need for clear policy guidelines and for the direction which pre- and in-service training should take. There is an obvious distinction to be drawn here between the situation in decentralised countries such as the United Kingdom and the United States, on the one hand, and a centralised country such as France on the other. The distinction is especially illuminating given the amount of development work done in each of these three countries; this is covered in the background reports on these countries (Valérien, Edmondson, Estes and Hess and Miura). It is clear from the report prepared by M. Valérien that the teacher training initiative for the NIT in France benefits from fitting into an overall plan which includes both curriculum materials development and a strategy for creating a multiplier effect. Personal contact with colleagues who work within the French system suggest that this has generated a sense of direction which could well be echoed elsewhere. It appears also to be a strength of the French programme that professionals who are closely involved in the teacher re-training scheme (upon which an important emphasis has been placed) are closely consulted about, and contribute to, the development of policy.

89. The picture in the decentralised countries is very different. The United States reports reveal a wide range of initiatives being taken in the various States, without there being any necessary uniformity of approach in any one State. Leadership groups emerge by a natural process, but again to a local, not a State or national, pattern: a City administration here, a teacher training centre there, elsewhere a research centre such as that of the MIT LOGO Group, a Parent Association, a group of teachers or even an individual. Any one of these bodies may have, in a given setting, a decisive influence on development. The picture is very similar in the United Kingdom. Much has been made, quite rightly, of the important role played by the MEP, which has been in many ways a remarkable development in a country with as strong a tradition of decentralisation as the United Kingdom. But the role of MEP is essentially that of resource co-ordination, of stimulus and of launching of curriculum development activity, coupled with an element of teacher training limited mainly to short sensibilisation courses. In no sense is MEP intended as a vehicle for the development of a national policy. As a consequence, the initiatives which are of long-term importance in respect of teacher training for the NIT are those of the teacher training institutions themselves and of the Local Education Authorities, through their Advisory and Teachers' Centre

84. Hardware resources, of course, are not necessarily available to all teacher training institutions, and there are resourcing problems to be faced on a large scale in many countries. Nor is this a question of hardware alone; it is a commonplace of business use of the NIT to look first for software appropriate to needs, and to worry about the hardware later. The same situations cannot yet be said to apply in education, since the hardware is considerably more in evidence than is software which will truly stand up to educational scrutiny. Nonetheless, this too is beginning to emerge, and it places upon the budgets of teacher education institutions a heavy burden of purchasing in a period when this particular sector of the education system, in a number of countries, is particularly subject to cut-back.

85. But the major resource problem is the human one. The proportion of teacher trainers with Information Technology as their "subject" is even lower than for teachers at secondary level. In those countries which allow professional movement laterally across disciplines, this has been the solution which has emerged -- very often, of course, it has been Mathematicians who have provided the input. (The author of this report is unrepentant of having moved into the teaching of Information Technology from the totally "opposite" end of the curriculum spectrum, namely English Literature.) In countries where the teaching of a discipline is relatively strictly linked to possession of an academic qualification -- Germany is a case in point -- a severe problem exists. Nor can the problem of human resources be ignored in a country traditionally as flexible in its attitudes to subject qualifications as the United Kingdom, since the flexibility in the system is balanced out by what amounts to, effectively, a standstill on recruitment into teacher training for almost a decade. The need to re-train the trainers, if they are in fact to be able to train their own subject-area students, is acute.

C. Research and Development

86. One of the problems facing teacher education is that of knowing which direction to follow in the provision made for students at both pre- and in-service levels. In a highly dynamic area such as the NIT, those involved in teacher training find themselves of necesssity attempting to keep abreast of a range of developments. And the breadth of this range must not be underestimated; it encompasses the latest in educational software, which needs to be examined and evaluated, trends in the field of business applications, from which the educational world has so much to learn, new languages which appear to offer valuable directions for teaching (COMAL, LOGO, micro-PROLOG...) new applications packages (word processing, spreadsheet...), indications of policy directions and also the latest information from the world of academic research (Artificial Intelligence, expert systems...). The list is daunting, to say the least. What it calls for is an involvement on two fronts, namely those of professional development and of research. These, of course, are not necessarily the same, and both are important.

87. There is a considerable body of evidence, much of it subjective and uncorroborated but substantial nonetheless, which suggests that circumstances inhibit an adequate participation by teacher educators in research in this, or in many cases any, area. The circumstances can be varied. In some education systems, research as such is not seen as the province of teacher training;

activities. (It may indeed prove to have been the case that the concentration of effort at national level on the MEP has distracted both attention and resources away from the more permanent agencies of training.)

90. Nothing in life, of course, is as simple as the two preceding paragraphs might seem to suggest. It is not a straightforward case of the centralised system scoring heavily over the dencentralised: far from it. The very real strengths of the decentralised systems lie in their ability to let a thousand flowers bloom. As a consequence, the sheer diversity of the developments which have taken place in the United States and the United Kingdom have led to a great deal being learned about the range of contributions which the NIT might make across the curriculum and at all levels, while the centralised approach is at the same time more organised and thorough, but also more limited in the range of what it does.

91. At the heart of the dilemma there stands the teacher trainer, whose contribution, all are agreed, is of the highest importance but who risks, on the one hand, working to a pattern which is, relatively speaking -- the qualification is highly important -- "handed down", or on the other, working in a policy vacuum and having to carry, probably with a small group of colleagues, a heavy responsibility for the direction taken by the teacher training (and consequently by the teachers who are trained). If a choice has to be made between the two poles of centralised and decentralised approaches, it is certainly tempting to say that, given the complexity of the whole NIT phenomenon, and given also the extent of investment in time, money and human resources called for, the former has a number of advantages. It is here worth quoting a remark made in the United Kingdom report by Maurice Edmondson, until recently a member of Her Majesty's Inspectorate in the highly decentralised British system: "The blending of initial training with a programme of continuous refreshment and up-dating by means of in-service courses in desirable and national guidelines on how best this might be designed and arranged would be helpful."

E. Teacher Training and the NIT: the Prospect for Success

92. In the foregoing paragraphs we have identified some of the major problems faced by teacher education as it attempts to measure up to the challenges of the new technologies. The problems, as we have said, are to some extent circular. Without clear policy guidelines, for example, there is no clarity as to the kind of training to be given to teachers or to teacher trainers. But the lack of trained expertise in the educational use of the NIT is itself a contributing factor to uncertainty about policy directions. The teaching undertaken by trainers is often not as well supported by involvement in research and development as it might be; this is partly because trainers in this field are so much in demand. And so forth: there is a real danger that the contribution expected of teacher education will be crippled from birth, if not stillborn.

93. If teacher education is to make its essential contribution -- as all within the training sector would undoubtedly wish it to do -- then it would seem that a number of facts need to be faced. These are partly, and importantly, to do with resourcing, and overall to do with the creation of a climate for development.

94. The resourcing required falls under three main headings:

i) The institutions which train teachers will need a considerable investment in physical resources. These will include both hardware (which will carry with it, for the foreseeable future, a need for renewal over, possibly, a three- or five-year cycle to keep provision up-to-date) and software. The importance of this latter, especially in countries where educational software, and software with a relevance to education, is likely to be produced by the private sector, is considerable;

ii) It will be necessary to invest heavily in the retraining of the trainers themselves to enable them to introduce the NIT into their work across the curriculum. Nor can this be seen as a "one off" process. The pace of change is likely to make a semi-permanent system for up-dating the NIT skills of the teacher trainers essential. (It should be added that the term "trainer" here refers to those who train the generality of teachers. It will be equally important to up-date the skills of those who train the trainers -- i.e. those who are versed in the new technologies will also need refresher experience).

iii) It is highly unlikely, in many cases, that the training programmes required can be inserted into existing workloads, which are already very high in this area. It seems inevitable that providing bodies will be faced with the need to recruit new and additional staff if adequate responses are to be mounted.

There would appear to be a strong case, at policy-making levels for a review of requirements in these areas.

95. Clearly, the further strengthening of resources in these ways would do a great deal to enable teacher education to meet the NIT challenges. What are additionally needed are the two elements already identified: a more effective link with research and development, and, in some countries, clearer policy lines for development.

96. Each of these, of course, feeds from the other, and it is worth examining more closely the ways in which research and development could aid the better formulation of policy guidelines. The key point here would seem to be the interpretation put upon the concept of research, and it appears essential that this be not construed simply in terms of scientific research alone.

97. Scientific research has an extremely important contribution to make; we have referred already to developments in Artificial Intelligence and in storage technologies. It is essential that developments in the field of teacher education be able to take cognisance of these and similar advances. Additionally, however, we have stressed throughout this report the importance, in educational terms, of the applications of the NIT, and have drawn attention also to their wider implications. Thus the construction of a strategy for the training of teachers has to take into account developments which cover a very wide range: these include, for example, the use of public data banks as resources for learning, enhanced uses of the broadcasting media (vide Maddison, 1983) for the delivery of learning packages, examination of new

patterns of work and leisure, questions of individual privacy -- and so forth. Responses to such a wide range of phenomena, which embrace technological development, pedagogical application and social implication, are surely too complex to be decided by any one sector alone. What happens in education as a consequence of these new developments -- in short, what teachers in the future will do, what functions they will fulfill -- cannot be determined solely on the grounds of technological/scientific trends or by fiat of political leaders -- and certainly not solely by teacher trainers having to make up their own minds about what to teach.

98. Two steps would appear to be essential. The first step would be the creation of settings in which careful, controlled experiment could take place. Such settings would need to be large enough to sustain a viable range of uses of the new technologies, and also large enough to involve a representative cross-section of interests in guiding development. Equally, they would need not to be so large as to involve entire education systems, or to create undue problems of co-ordination. The precise nature of the seetting is not critical. It could equally be a medium-sized city or a rural area with a more widely distributed population. What matters is that, within our various education systems we establish in such selected settings a commitment to development across the entire spectrum of educational services and levels, from pre-Primary to teacher education and incorporating the education of children of all abilities and in all settings (the hospital or home as well as the schools). While the development activity would be led by the responsible educational authority -- since its goal would be to map out a total and integrated set of answers to the insertion of the NIT into education -- it would draw also upon the expertise of local commerce and industry, of the NIT industry itself, of media and of publishers, of trade unions, parents, teachers, cultural and social interests (including minorities) and, of course, teachers. National authorities and examinations boards would need to be involved also. If a dialogue could be established on such a wholistic basis -- taking a community-wide look at a phenomenon which affects the whole community -- and properly resourced, then there might be a chance that we should arrive at wholistic solutions. Specifically, we might arrive at a view of the new functions demanded of the teacher, and consequently of the task required of teacher training and retraining, which was based on more than the circumscribed and entirely ad hoc set of actions which we are perpetrating at the moment.

99. The second step would be a logical -- surely? -- extension of the first. Given the broad similarities of socio-economic organisation which override the cultural differences between most of the developed nations, it is reasonable to see the educational problems posed by the new technologies as being, again broadly, the same from country to country; the technology itself transcends national boundaries. Yet anyone involved in examining the NIT/education phenomenon at the level of Europe only, let alone the wider membership of OECD, has to be conscious of how little is done, in real terms, to share development costs in what is, by normal education budget standards, an enormously costly phenomenon. It is not difficult to envisage the benefits that could flow, in terms of experience gained, insights shared and, also, concrete joint actions on, for example, software, if it were possible to establish a network of the kind of developmental settings outlined in the previous paragraph, perhaps no more than two or three in any one country. It would not be necessary for each to follow a shared line of development -- indeed, the reverse. Since the future pattern of educational use and

provision in the wake of the NIT cannot be predicted, it would be immensely valuable to have a number of linked but separate and diverse activities proceeding in parallel but sharing from each other's learnings. Strategies of this kind, admittedly, go beyond what has hitherto been attempted: we are talking of curriculum development on a very large scale indeed. But the point is precisely that it is development on this large scale that the new technologies may demand. And they are, after all, technologies of information: it requires little imagination to see how the new, enhanced communications technologies could be put to serve a network of the kind outlined.

100. Whatever strategies we adopt to face up to the inevitabilities of development, two things, finally, stand out. One is that we cannot much longer evade a thorough-going assessment of the deep changes which the technologies of information call forth in the function of the teaching profession. Whether that re-assessment follows the pattern outlined here or not, is immaterial. All that this paper attempts to do is to suggest that a framework for analysis has become possible and that we can no longer justify the ad hoc. The second point which stands out is that, whatever set of changes in teacher functions finally emerges as dominant in the wake of the NIT, the response of teacher education will be critical, inevitably, in the process of helping the teaching profession to adapt to these changes. A continuing and serious investment in the resourcing of the capacity of teacher education to make the required contribution seems to be, even more than ever, crucial to development.

BIBLIOGRAPHY

Abelson, H., and diSessa, A. (1981), *Turtle Geometry*, (Cambridge Mass., MIT Press).

Akkermans, J. and Plomp, T. (1982), "Information technology in Dutch Education: will there be a National Policy?", (*European Journal of Education*, Vol.17, No.4.

Aldrich, M.J. et al. (1982), *Report on Cable Systems*, (London HMSO).

Atherton, R. (1982), *Structured Programming with Comal*, (Chichester, Ellis Horwood).

Beech, G. (1983), *Computer Based Learning* (Wilmslow, Sigma Press).

Boden, M. (1977), *Artificial Intelligence and Natural Man*, (Brighton, Harvester Press).

Bossuet, G. (1982), *L'ordinateur à l'école*, (Paris, Presses Universitaires de France).

Bossuet, G. (1982), "L'appropriation de l'outil ordinateur par les enseignants en formation", (*European Journal of Teacher Education*, Vol.5, No.s 1-2).

Brown, M.J. (1983), "The Complete Information Management System", (*Byte*, Vol.8, No.12).

Callegari, M. & O'Connor, B. (1983), "The Data-interchange Dilemma", (*Byte*, Vol.8, No.12).

Cerych, L. (1982), "Computers in Education: Major Problems and Key Policy Issues", (*European Journal of Education*, Vol.17, No.4).

Christiansen, B. (1982), *Beginning COMAL*, (Chichester, Ellis Horwood).

Chang, D. (1983), "An Introduction to Integrated Software", (*Byte* Vol.8, No.12).

Clark, K.L. & McCABE, F.G. (1984), *Micro-PROLOG: Programming in Logic*, (New Jersey, Prentice-Hall).

Duke, J. (1983), *Interactive Video: Implications for Education and Training*, (London, Council for Educational Technology).

Ennals, R. (1983), Beginning micro-PROLOG, (Chichester, Ellis Horwood).

Eisenberg, J. & Hill, J. (1984), "Using Natural-language Systems on Personal Computers", (Byte Vol.9, No.1).

Evans, C. (1979), The Mighty Micro, (London, Gollancz).

Gallouedec-Genuys, F. & Lemoine, P. (1980), Les enjeux culturels de l'informatisation, (Paris, La Documentation Française).

Garland, R. (1982), Microcomputers and Children in the Primary School, (Brighton, Falmer Press).

Goodall, A. (1983), PROLOG, (Wilmslow, Sigma Press).

Gorny, P. (1983), New Information Technologies and Education: Germany, (Brussels, Association for Teacher Education in Europe).

Gorny, P. (1982), "New Information Technologies in Education in the Federal Republic of Germany", (European Journal of Education, Vol.17, No.4).

Gwyn, R. (1981), The New Information Technologies and Education: Implications for Teacher Education, (Brussels, Association for Teacher Education in Europe).

Gwyn, R. (ed.) (1982), Teacher Training and the New Information Technologies, (Brussels, Association for Teacher Education in Europe).

Gwyn, R. (ed.) (1982), Information Technology and Teacher Education: Perspectives on Development, (Brussels, Association for Teacher Education in Europe).

Gwyn, R. (1982), "Information Technology and Education: the Approach to Policy to England, Wales and Northern Ireland", (European Journal of Education, Vol.17, No.4).

Gwyn, R. (1982), "Information Technology and Education: a Context for Development", (European Journal of Teacher Education, Vol.5, No.s 1-2).

Fothergill, R. (1981), Microelectronics Education Programme: the Strategy, (London, Department of Education and Science).

Heaford, J.M. (1983), The Myth of the Learning Machine: the Theory and Practice of Computer-based Training, (Wilmslow, Sigma Press).

Jensen, T. (1982), "New Information Technologies and Education in Denmark", (European Journal of Education, Vol.17, No.4).

Johnson, C.E. (1983), "The Promise of Perpendicular Magnetic Recording", (Byte, Vol.8, No.3).

Large, P. (1980), The Micro Revolution, (London, Fontana Press).

Large, P. (1984), The Micro Revolution Revisited, (London, Futura Publications).

Laurie, P. (1980), The Micro Revolution, (London, Futura Publications).

Lawler, R.W. (1982), "Designing Computer-based Microworlds", (Byte, Vol.7, No.8).

Lemmons, P. (1984), "Beyond the Word Processor", (Byte, Vol.9, No.1).

Lewis, R. & Tagg, E.D. (1981), Computers in Education (two vols), (Amsterdam, North-Holland).

Maddison, J. (1983), Education in the Microelectronics Era, (Milton Keynes, O.U. Press).

Mateosian, R. (1984), "1984, The Year of the 32-bit Microprocessor", (Byte, Vol.9, No.1).

Mills, M. (1984), "Memory Cards - a New Concept in Personal Computing", (Byte, Vol.9, No.1).

Ministère de l'Education Nationale, France (1981), Programme d'action pour le développement de l'informatique et de la télématique dans l'enseignement, (Paris, Ministère de l'Education Nationale).

Ministere de l'Education Nationale, France (1981), L'informatique au lycée, (Paris, Ministère de l'Education Nationale).

Nora, S. & Minc, A. (1978), L'informatisation de la société, (Paris, la Documentation Française).

O'Shea, T. & Self, J. (1983), Learning and Teaching with Computers, (Brighton, Harvester Press).

Parsloe, E. (1983), Interactive Video, (Wilmslow, Sigma Press).

Papert, S. (1980), Mindstorms: Children, Computers and Powerful Ideas, (Brighton, Harvester Press).

Perriault, J. (1980), "Offre informatique et choix d'éducation" (Gallouedec-Genuys, q.v.).

Perriault, J. (1982), "Les jeunes, l'informatisation et les multinationales", (Le Genre Humain).

Roberts, N. et al. (1983), Introduction to Computer Simulation, (Reading Mass., Addison-Wesley).

Ross, P. (1983), LOGO Programming, (London, Addison-Wesley).

Rothchild, E. (1983), "Optical-Memory Media" (Byte, Vol.8, No.3).

Schwartz, B. (1981), L'informatique et l'éducation, (Paris, la Documentation Française).

Simon, J-C. (1980), L'éducation et l'informatisation de la société, (Paris, la Documentation Française).

Stonier, T. (1983), The Wealth of Information, (London, Methuen).

Toffler, A. (1973), Future Shock, (London, Pan Books).

Toffler, A. (1980), The Third Wave, (London, Collins).

Van Weert, T.J. (ed) (1984), Information Technology Literacy for all Teachers (Brussels, Association for Teacher Education in Europe).

Vose, G.M. (1984), "1984 and Beyond" (Byte, Vol.9, No.1).

Watt, D. (1982), "LOGO in the Schools", (Byte, vol. 7, No.8).

Watt, D. (1983), Learning with LOGO, (New York, McGraw-Hill).

Yazdani, M. (1984), New Horizons in Educational Computing, (Chichester, Ellis Horwood).

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CHANGES IN CURRICULA AND INSTITUTIONAL STRUCTURES

1. The attached document has been prepared by Peter Bollerslev, Head Teacher, Taastrup, Denmark, and Nolan Estes, Professor, University of Texas at Austin, United States, in their capacity as consultants to the Secretariat. It will serve as one of the background reports for Working Groups 2, 3 and 4.

2. The views expressed are those of the authors and do not commit either the Organisation or the national authorities concerned.

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INTRODUCTION

1. As foreseen in many of the national reviews analysed in the report CERI/NT/84.02 the introduction and use of new technologies in education has already caused or is expected to cause changes in curricula and institutional structures. This synthesis report analyses the trends concerning changes in curricula and institutional structures on the basis of a number of case studies from Australia, Belgium, Canada, Denmark, Japan, New Zealand, the Netherlands, Turkey, United Kingdom and United States. The case studies were carried out in 1983, most of them in late 83. The very extensive USA-study was based on a questionnaire developed at University of Austin, Texas. The other case studies were based on a questionnaire drawn up on the basis of the USA-model, but not going into as many details.

2. The report is divided into four main parts. The first chapter deals with primary and lower secondary education, the second chapter looks at upper secondary education, the third chapter is on further and higher education and chapter four deals with distance education at various levels. The trends found in each part are based on rather few case studies. As the countries differ very much due to geography, educational systems, political circumstances etc., it is not easy to learn from experience in another country. Therefore no comparisons are made between countries.

3. In the report there are many quotations from the case study reports, as these statements express "hands-on-experience" about the trends.

Chapter I

Primary and Lower Secondary Education

A. Changes in Curricula

4. Generally, the elementary and middle school curricula have been impacted by the new information technologies by the incorporation of two new technology-related facets: (1) teaching with computers (computer-assisted instruction), and (2) teaching about computers (computer literacy, computer science, programming). The international case studies report wide variations in the extent to which elementary and middle schools use technology for these purposes, as well as in the level of student and subject matter targeted. Many of the schools and school districts are in the initial phases of planning or implementing the use of technology for instructional purposes. Nevertheless, some generalisations are possible.

5. The most frequently reported use of technology at the elementary level is for computer-assisted instruction in reading and mathematics. Generally, this takes the forms of drill and practice exercises, enrichment activities, and remedial activities.

-- In the United States, very minimal use of technology is reported for problem solving, simulations, or the development of reasoning skills.

-- In the Denmark study, a focus is placed on problem-solving, which has been found to have a great pedagogical effect in terms of transfer to other subject areas.

-- In the United Kingdom study, the computer has provided the students a method for handling primary source data, which would not otherwise have been possible.

-- The Australian study illustrates the successful application of computer-assisted instruction to the area of handwriting. The procedure for teaching handwriting skills has been radically changed as a result of the introduction of the technological approach. Since the technology is used to present exercises, teachers have spent a greater proportion of the time in reviewing curriculum materials and deciding which materials suit individual students. In essence, the repetitive aspects involved in the traditional forms of teaching handwriting have been replaced by a computer presentation which offers significant advantages. It was found that changes in curriculum had taken place because teachers have started to use the technology as a classroom research tool in that they have begun to experiment with varying curriculum materials for different students. Thus, the technology has given teachers a powerful tool with which to plan appropriate curriculum strategies.

6. Teaching about computers is generally introduced at the upper elementary or middle school level.

-- Some of the districts in the United States study defined "computer literacy" through the development of a list of objectives or skills that students are expected to master at a given level. In some cases, these objectives define a new "strand" of the curriculum parallel in structure to a language arts or mathematics strand. In other cases, the objectives are added to an existing strand, such as that of mathematics or science, but no real integration has been reported.

-- The Council of the Great City Schools (Attachment D to the USA study) reports that many large districts do not have a computer literacy course, per se, but rather infuse literacy throughout the curriculum as part of their computer-assisted instruction plan.

-- The Denmark study describes a mandated subject for grades 5 to 9 in which the students are taught about the positive and negative societal implications of the new technology as well as programming and information about the hardware.

7. Overall, the new information technologies have had only a moderate impact on the elementary and middle school curricula. Most elementary curricula have remained unchanged, with teachers using the computer as another teaching tool to support or supplement the regular program of instruction. Computer literacy courses may be introduced at the middle school level, but not in any interdisciplinary fashion. It is too early to be certain as to how the introduction of new technology is affecting the curriculum. From the experience to date we are just able to draw indications as to possible future developments. Some of the teachers questioned whether anything new was being done with the computer that had not been done before albeit in other ways.

The introduction produces side effects as the high level of motivation and skills developed using the computer are transferred to other activities.

- -- The United Kingdom study and the US Congress, Office of Technology Assessment Report, both cite the lack of good software as a major limitation in the application of technology to education. This shortage of software can lead to an undesirable effect on the curriculum, namely it can distort it: activities are undertaken that fit the availability of particular software rather than meeting needs.

- -- The report by the Council of the Great City Schools (USA) points out the difficulty in altering elementary curriculum because of the need for more broadly based curriculum revision at that level.

- -- The Denmark study states that no formal changes were made in the curriculum that the new computer "informatics" course lessons were simply added to the normal timetable. However it was found that the experiences from this new area influenced the teaching of other subjects. The new subject could be characterised as having interdisciplinary qualities.

B. Changes in the Teaching/Learning Environment

8. The use of new information technologies has definitely increased individualisation of instruction, but only for special populations of students, particularly students who are handicapped in some way.

- -- The Australian handwriting program was originally developed for mildly intellectually handicapped pupils. Equipment to suit the given learning task was devised and adapted. The educational objectives were not compromised to suit readily available equipment.

- -- The United States study reports that the students most involved with computers are those who are either high- or low-achievers, due to (1) pre-packaged software being geared toward either drill and practice/remediation (for low-achievers) or enrichment activities (for high-achievers), and (2) government resources being most available for students of special populations.

- -- The Commission of the European Communities reports the use of computers for teaching a wide range of handicapped students, from those with cerebral palsy, [illegible]sm, or severe motor impairment to those who are [illegible] deaf, or non-lingual.

9. Only a few school districts report the use of computer-managed instruction, that is, using computers to record students' progress through the instructional program.

- -- One of the Dutch case studies describes a primary school for foreign students in which the computer is used for testing and assignment purposes.
- -- A large district in the United States study reports a similar district-wide use of computer-managed instruction.

10. Because of the restricted scope of the international case studies, it is difficult to estimate the actual numbers of students and teachers who utilise computers on an ongoing basis. However, the limited evidence available indicates that these numbers at the elementary level are relatively small.

- -- The United States report estimates that the number of students and teachers involved in some computer-related instruction ranges from as little as 2 per cent to as much as 100 per cent in a given district. The average seems to be about 10 to 25 per cent of the students involved at the present time, which includes both elementary and secondary education.
- -- A survey conducted by the US Council of the Great City Schools indicates a ratio of one computer for every 863 elementary (K-6) students.
- -- While the United Kingdom Government schemes have been highly successful in encouraging schools to acquire micro-computers, the volume of hardware purchased is still a long way from that which would enable significant change to take place in the provision of learning opportunities. A recent survey from the DES and Schools Broadcasting Council indicates that every secondary school and a third of all primary schools now have a micro-computer but this still means that there is only one micro-computer for every 200 pupils.
- -- In Denmark approximately 20 per cent of the primary schools (February 1984) are equipped with micro-computers. There is a ratio of one computer for every 125 pupils.

11. New information technology seems to generally have a high impact on the attitude of students, teachers, and parents. The changes that occur in curricula and the implications for the teaching/learning environment are closely linked to the way in which the technology is being used. The computer-based presentation has obvious advantages over conventional procedures. It should be made clear to teachers that a program's effectiveness is related very strongly to the way in which they use it. In this way, teachers concerned will not consider the computer as a threat to their profession but as a powerful teaching tool which they can utilise.

-- The Australian study emphasizes the strong increase in motivation and attention span of normally distractible students when using the computer. Similarly, this study reports high enthusiasm from the teachers who view the computer as a very powerful teaching tool.

Within the teachers, the women showed a change in attitude. Their initial attitude to the role of computers in education could be described as that of scepticism, but at the end of the field trials, all teachers were positive and enthusiastic. Their previous attitude to the role of technology in education was based on their perception of computers as being for mathematics and "shoot-or-be-shot" games, both male dominated areas. The use of computer-based handwriting instruction was their first introduction to areas of curricula which they perceived as being within the domain of women.

-- The United Kingdom study indicates that interest in computers is shared by both sexes across a multi-ethnic clientele. The findings show that some parts of the curriculum appeal more to boys than girls and vice versa, and that boys would find it more interesting to use computers than girls do. But it was also found that at this age level both boys and girls appeared to be making equal use of technology and developing the same new skills in this extension of the curriculum: "computer awareness" or "information skills". However this study also cautions against pushing technology too hard or too fast because of the negative impact that might have on teacher attitudes.

-- Districts interviewed in the United States study reported strong pressure from parents to institute computer programs. Unfortunately, this is not accompanied by much in the way of home-based computer learning.

-- In the United Kingdom study, the gains achieved by certain children using the computer were well above the teachers' expectations of what they would achieve. In fact, the teachers most involved with the computer indicated that it would be used to encourage children to be more independent and take greater responsibility for their own work.

C. Changes in Institutional Structures

12. Because the United States study covers 25 case studies, as opposed to one or two from each of the other countries, the changes in the institutional structures noted in the United States study will be conveyed here in extenso. Many of these apply to the international scene as well. These changes are manifested in the form of policies being followed by the various districts.

13. Indications of policy changes related to technology are apparent in all the respondent districts. Some governing boards have stated explicit policies, others have indicated implicit policies through certain actions or programmes, while others are at the investigative stage of policy-making. The observed policy changes have affected five areas: (1) the instructional programme, (2) financial allocations, (3) administrative staffing, (4) physical facilities, and (5) communications.

14. Policies regarding the implementation of technology in the instructional programme fall into two types: those that focus on the student and those that focus on the teacher. Some districts have addressed their policies to the curriculum and what each student is expected to learn. Others have focused their policies on teacher training and what new competencies teachers should demonstrate. A few districts have developed plans which have integrated both these components. Many governing boards are considering or have already instituted new requirements for graduation which include a demonstration of computer literacy. The extent to which "computer literacy" is explicitly defined varies greatly from district to district. A few districts have mandated teachers to take some computer training which is arranged by the district. Some districts will not approve a school's purchase of hardware until an appropriate number of teachers have been trained. One respondent district requires that all the teachers pass a certification test to indicate knowledge of computers.

15. Policy changes are most evident in the area of financial allocations. The implementation of technology is expensive, and districts have utilised a wide variety of strategies to meet the costs of this endeavour. A critical point which must be noted is that even in districts which are reducing staff as a budget measure, resources are being found to purchase computer hardware and software.

i) Many districts are directing state and federal funds, particularly those targeted for special populations, to the purchase of computers.

ii) Some districts are utilising state textbook money for the technology effort.

iii) Some districts are redirecting funds allocated for library books, media equipment, and basic supplies to the purchase of computer equipment.

iv) Parent-teacher organisations are helping some districts to purchase computers.

v) An increasing amount of resources is being provided by the private sector. Technological businesses in particular have been providing school districts with expertise, equipment, and financial assistance for technology. One district's governing board has a policy to match funds given by any outside source for technology. Other districts are working in conjunction with computer companies for the development of software to meet the district's needs. Several computer companies offer teacher training as part of a computer purchase.

vi) Some governing boards have added the costs of the technology effort to the regular budget of the district.

16. Nearly all districts have addressed the need to designate administrative staff to co-ordinate the technology effort in the district.

i) Most districts have hired at least one and usually more new central office administrators to plan and co-ordinate the implementation of technology in the instructional and/or management area of the system.

ii) Two large respondent districts have established a Department of Technology. The functions of such a department may include centralised procurement of hardware and software, evaluation of hardware and software, maintenance, teacher training, and implementation assistance to individual schools.

iii) Some districts prefer to utilise all levels of staff in the planning and implementation efforts, rather than to designate specialists for one role.

iv) Some small districts have added new technology-related responsibilities to the assignments of existing staff members, rather than hiring new staff.

17. All respondent districts reported policy changes with regard to the provision and utilisation of physical resources.

i) Many districts have established or plan to establish a computer laboratory in each school building. Often space is made available from empty classrooms, with appropriate rewiring and security measures added.

ii) Some districts prefer to have the computers available in each classroom, particularly at the elementary level. In this situation, the computers are usually kept on desks designed to be easily moved.

iii) Some schools have integrated the computers into the school library or existing media centre.

iv) Several districts which are planning the development of new school buildings have modified the architectural designs to include computer laboratories.

18. Changes are evident in most districts in the amount and type of communications, both in-house and to parents and the public, that have occurred as a result of the new technology.

i) Most districts report a definite improvement in the information delivery system to their governing boards, both in quantity and quality of information.

ii) Some districts report that members of their governing board show a greater selectivity and sophistication in the information requested.

iii) Better information is available to the public in several districts as a result of using cable television and word processing equipment.

iv) In several districts, administrators use closed-circuit television and radio to communicate with staff in local schools.

v) In several districts, technology is used to communicate with parents in a more timely and accurate way than ever before. Districts report using the computer to notify parents regarding school assignments, immunisations, absences on a daily and per class basis, report cards, grades, and test results. One district cautions against sending too much or too complicated information to parents, simply because the information is now so easily available.

Chapter II

Upper Secondary Education

A. Changes in Curricula

19. The impact of technology on upper secondary curricula is most evident in the addition of computer science courses and other computer-related courses in mathematics, science, and vocational education (e.g., job training courses).

-- The survey conducted by the US Council of Great City Schools indicates that all the large districts but one offer computer science courses, averaging about seven different such courses per district. In general, these course offerings focus on programming skills or computer theory.

-- One of the New Zealand case studies describes a secondary school which has implemented computer studies courses as an optional subject over a three-year sequence. A variety of topics are included, which are presented at more advanced levels of understanding each successive year.

-- One of the Dutch case studies describes a school for general secondary education in which computers are used for a computer science course, a test service system, and remedial teaching.

-- The Belgian study describes the use of computers in three secondary technical schools for teaching vocational training in the areas of accountancy and bookkeeping.

-- The vast majority of the districts described in the United States study have added new computer-related courses at the secondary level. Many districts reported much greater impact on the secondary curricula than on the elementary level.

-- In the United Kingdom case study of secondary education, computing studies courses are offered in which students learn at least three different computer languages and work in close contact with local businesses on real projects. In addition, a special course on Microcomputer Applications is offered.

20. The impact of technology at the secondary level is most evident in the addition of new courses, less evident in the modification of existing courses, and minimally evident in terms of interdisciplinary involvement.

-- The United States study indicates that the only modification of existing courses has occurred in the areas of mathematics, science, and vocational education. Other subject areas are relatively untouched by the new information technologies.

-- An exception is reported in a New Zealand case study in which the introduction of microcomputers has caused an increased awareness among the staff and students about some of the social implications of the new technology. As a result, a 12-hour module on "computer awareness" has been added to the Social Studies curriculum.

-- Another notable exception is described in the United Kingdom case study on secondary education. Computer awareness has been introduced as an essential element in each of the major subject areas of the core curriculum (mathematics, science, European studies/English, and humanities). In addition, the use of information technology has been gradually developed in science for simulation and data capture, in technology for design and drafting, in music for practice and self-correction in the learning of chords and intervals, in English for the development of linguistics and logical problem-solving, and in remedial courses for children with learning difficulties.

-- The United Kingdom secondary case study, the US Congress Office of Technology Assessment Report, and New Zealand's Case Study No. 2 cite the lack of high quality and appropriate software. In the United Kingdom study, teachers developed about 25 per cent of the software they use.

-- The vocational training programme described in the Belgian study implies some interdisciplinary involvement in that other subjects such as business law, economics, and management have been integrated with the use of technology.

B. Changes in the Teaching/Learning Environment

21. Little, if any, individualisation of instruction has been promoted by the use of technology at the secondary level.

-- The Belgian case study does report an increase in individualisation in that each group of three students creates a simulated business enterprise related to those students' progress. It is unclear, however, how the use of technology enhances this, since similar activities could be conducted on paper.

-- One of the Dutch case studies did not witness any increase in the degree of individualisation of instruction. However, student performance improved as a result of more structure and therefore more careful work.

-- A New Zealand case study points out the need for good quality and inexpensive software to meet the individualistic needs of students in order for them to work at their own level of ability, whether they be gifted or slow learners.

22. Teachers in the computer-related subject areas have learned new skills and modified their curriculum methodology accordingly.

-- Some of the districts in the United States study indicate that the teachers are forced to learn the new skills when they are mandated to teach new courses.

-- The Belgian case study indicates a use of new curriculum methodology by the teachers.

23. As with the primary level, it is difficult to estimate the numbers of secondary students and teachers who are involved with the use of computers.

-- As reported by the US Council of the Great City Schools, the ratio of students to computers is vastly improved over the primary level, with one computer available for every 186 secondary (grades 7 to 12) students.

-- In the United Kingdom every secondary school has at least two microcomputers.

-- In Denmark every secondary school has at least eight microcomputers with a ratio of one computer for every 40 students.

-- The districts in the United States study generally could not estimate the numbers of students enrolled in the various computer science courses.

24. The impact of the new information technologies on the attitudes of secondary teachers, students, and their parents is generally favourable.

- The attitudes of staff in a New Zealand case study toward the introduction of computers are reported as highly positive.
- The majority of teachers in the United States study who participated in some computer-related training are described as having changed from a skeptical to a less fearful and more enthusiastic point of view.
- The students, teachers, and parents in the Belgian case study all seem to appreciate the applied nature of the coursework.
- In the New Zealand case study, the impact of the microcomputers on the students' attitudes are reported as very individualistic, although generally favourable. Some instances are cited of students who lost interest in the computers presumably because of lack of time and facilities, as well as lack of appropriate software for their needs, while others became obsessed with the Computer Studies to the exclusion of all other subjects.
- Support from the parents in the New Zealand case study is evident in that funds were made available from the PTA (Parent-teacher Association) for the purchase of computer hardware for the school.

C. Changes in Institutional Structures

25. The changes reported under this section in Chapter I also apply to secondary education.

Chapter III

Higher and Further Education

A. Changes in Curricula

26. Colleges and universities vary greatly in the extent to which new information technologies have effected changes in the curricula. However, all of the institutions of higher education included in the various case studies report some change. Information technology subjects such as control technology already feature in the curriculum particularly in technical and vocational education. These may be accompanied by a reappraisal of the relationship between content and process as it relates to the need of providing young people with the necessary skills to cope with rapid social and technological change. In this context the introduction of information technology can be seen to be part of a more general debate about the purpose of education and the balance between the needs of the individual and those of society.

27. Changes are likely to take place in the existing patterns of organisation in education in order to realise the full potential of information technology. In some cases this may demand the creation of new structures. This may happen relatively easily in the vocational and training sectors where outcomes are more readily measured. Here the introduction of information technology may demonstrate cost advantages and/or allow training to take place in more flexible circumstances.

- -- At the low end in the United States study, computer awareness or literacy courses are an available option to all students, and application courses have been added in the departments of mathematics, science, and business.
- -- At the high end in the United States study, all departments in the institution have integrated the use of technology into their degree programmes.
- -- The extent to which new information technologies have caused change in the United States higher education curricula is largely a function of the overall focus

of the institution: the more technical schools indicate higher impact than do liberal arts schools.

-- Differences in the amount of curricular change are also attributable to the fact that the United States technology instructional programmes surveyed are in various stages of development -- some in the first one or two years of implementing the use of technology for instruction while others have been abreast of technological progress for 15 years.

-- In a New Zealand case study, faculty reports structural and/or content changes as a result of NITs in just over half of the 66 courses surveyed.

-- In the United Kingdom study of further education, new techniques and systems have had an effect on the content throughout the range of courses offered. This is largely attributable to the fact that training in the use of technology is the "raison d'être" for the college surveyed. Throughout every area of the college there is a concern for real applications as well as theoretical understanding.

28. Training of pre-service teachers is an area of moderate impact in terms of curricular changes in higher education as a result of NITs.

-- Generally, United States teacher education courses utilise hardware and software that is representative of what is currently used in elementary and secondary schools. This is usually integrated into standard "methods" courses.

-- Several United States institutions offer new degrees that focus specifically on the application of technology to education, for example, a Master's degree in Instructional Technology.

-- Overall, the structure, content, and methodology of the United States education pre-service training courses have not been impacted to a substantial degree. The US Congress Office of Technology Assessment reports that teacher training colleges in the United States are providing adequate instruction to new teachers in the use of information technology.

29. Technology-related training of in-service teachers is largely being conducted by the school districts that employ them.

-- Most United States districts have an ongoing professional growth programme for their teachers, to which new courses related to technology have been added. These programmes typically are optional, are scheduled after school hours, and offer in-service credit to the teachers toward increased tenure or pay scale level. In some districts, this represents the entire teacher training programme in the technology effort; in other districts, this format is provided in addition to some more centrally-administered programme. The districts with this option report heavy teacher participation and interest for technology-related courses.

-- Several United States districts are mandating all teachers to participate in a centrally-administered training programme. In some cases, this learning is conducted during one school year. In other cases, the training is phased in over several years, usually starting with the teachers who will teach with computers first.

-- Some United States districts are providing training only for selected personnel, who are then expected to conduct training and/or act as a resource person at their local school. This responsibility is usually added to the staff person's regular duties (as teacher, librarian, assistant principal) with no additional salary.

-- A few United States districts have a decentralised training system, in which each school develops and implements its own training programme in line with the needs of the individual school. In some of these cases, the district will not approve a school's request to purchase computer equipment until adequate provision has been made for teacher training at that school.

-- The content covered in the United States training programmes ranges from programming and word processing skills to information about hardware, software, technical vocabulary, implementation strategies, operations, and classroom applications. Only a few districts focus on the broader aspects of technology and society, the future of technology, or the interdisciplinary integration of technology into the curriculum.

B. Changes in the Teaching/Learning Environment

30. Although the individualisation of instruction has not been significantly affected by the new information technologies in higher education, some notable exceptions do exist.

-- In two of the United States institutions of higher education, the students are able to work at their own pace in completing various course objectives on the microcomputer. In one of these universities, microcomputers are located throughout the dormitories, giving the students a great deal of flexibility in completing course assignments.

-- In the United Kingdom case study of further education, the college operates on a philosophy to insure that every student makes use of the new technology in ways that are relevant to his or her studies and will be transferable to future changes in the workplace.

31. Little has been reported on the effects of NITs on student achievement, reflecting a lack of evaluation of new programmes. One case study did address this issue.

-- In a New Zealand case study, about half of the faculty respondents commented on various effects of NIT on student achievement. The majority felt that NITs have a positive effect on student grades, with increased student understanding, reinforcement of concepts and interest and awareness. However, several also cited some negative aspects of NIT on student achievement, such as failure by those with little previous computer experience or the tendency to not take systematic notes because of the new environment of the computer. Such examples imply poor teaching methods rather than negative effects of the computer per se.

32. The general attitude of those in higher education toward the new information technology ranges from very positive to a more "wait and watch" stance.

-- In a New Zealand case study, most of the faculty respondents indicated staff satisfaction in terms of enthusiasm and motivation in participating in the development of new innovations. However, some of the respondents cited frustration in terms of lack of technical back-up support and access to equipment, as well as excessive amounts of time needed for preparation and providing extra assistance to students.

-- The United Kingdom study of further education states that in order for lecturers to change their attitudes towards teaching and learning, they must first recognise that a problem exists in their using traditional methods. The College is attempting to influence the attitude of staff through the use of NIT for administration and management.

-- The faculty in the United States higher education case studies range in attitude from full commitment to the NIT to healthy skepticism. Those in the former category believe that faculty and students must have the ability to interact with the machinery of the information age, while those in the latter category believe that the role that computers can play in instruction is highly overrated.

-- A New Zealand case study reports student attitudes ranging from increased interest, motivation, and enthusiasm to some resistance, fear, caution, and apathy. The majority were in the positive category.

C. Changes in Institutional Structures

33. A definite increase in financial allocations for NIT is noticeable in all the case studies of higher and further education.

-- The bulk of financial resources has been earmarked for hardware.

-- Several campuses have altered or plan to alter physical facilities to accommodate the increase in NITs.

-- Funds tend to be more available for course proposals that have a technological focus.

34. Institutions of higher education have added new courses within departments, new departments, and new degree programmes with a technological focus.

35. Although some of the colleges and universities report the centralisation of new purchase, planning, and decision-making regarding NITs, the majority allow individual departments and/or faculty members to develop their own plans.

-- A New Zealand case study points out that university departments and faculties have always cherished their autonomy. Unfortunately, this situation also tends to result in a measure of unnecessary duplication.

Chapter IV

Distance Education

A. Changes in Curricula

36. The impact of distance education appears to be greatest in the area of higher and further education, and much less at the primary and secondary levels of education.

-- The United States study reports that several school districts utilise instructional television, cable television, closed circuit television, and/or radio to supplement the regular programme of primary and secondary instruction. However, except in a few rare cases, these distance strategies are not extensively used for instructional purposes.

-- The US Council of the Great City Schools reports that the majority of city schools now have, or plan to have, cable capacity. In addition, about half of these districts use electronic mail, several have or expect to have video-disc, and a few are experimenting with robotics. Some districts operate their own television or radio stations. Again, these distance strategies are in initial stages of implementation for instruction.

-- For several years some city colleges in the United States have offered degree programmes through local television stations, with examinations taken at one central location. Often such programmes are targeted at people who work full-time, are restricted by handicaps, or are isolated in settings such as prisons. These programmes are not documented in the case studies, but are generally known. They typically consist of videotapes of on-campus lectures, with no capability of interaction between student and teacher.

-- A case study from Turkey reports the use of a video system for in-service training of teachers of hearing impaired children.

-- A case study from an Australian university reports several uses of distance education: (1) on-line access to the library catalogue; (2) regular communication links for electronic mail, electronic course material, data files, assignments, and assessments; (3) teleconferencing by telephone to allow group discussions among staff and students; (4) teleconferencing via satellite between staff and distance students; and (5) special support services with modified tape recorders for disabled people.

-- A case study from British Columbia reports on distance education through the use of telecommunications networks as a joint venture of government, universities, community colleges, and provincial institutes.

37. Although institutions involved in distance education initially expected no changes in the curricula as a result of the NITs, changes have in fact been noted.

-- The Australian university case study describes initial efforts to use the same teaching staff, the same syllabus, and the same examinations for the on- and off-campus students. More recently, the validity of this model is being questioned given the technological changes that have occurred.

They see the integrated model as making a virtue out of necessity as well as having inherent educational merit. It is becoming increasingly clear that the integrated model supports a fragmented system of distance education in which there are too many providers.

-- The British Columbia case study indicates that despite expectations to the contrary, certain changes do take place when courses are taken from the classroom setting and adapted for distance delivery. The content itself remains relatively unchanged, but the distance education product is improved, being better planned, organised, structured, and presented than the average lesson delivered to a regular classroom. Distance education courses also tend to be more varied and stimulating, because a multi-media approach is chosen. over the traditional "chalk and talk" in the classroom. On the other hand, the distance education product is also less spontaneous, relaxed, and informal than the traditional classroom presentation.

-- The British Columbia case study speculates that the distance education medium must inherently require cognitive shifts in the information-processing skills used by the distance students, but that such changes are invisible, intangible, and difficult to articulate.

-- The Turkish case study reports that the curriculum became more flexible and changeable with the advent of video-aided teaching.

B. Changes in the Teaching/Learning Environment

38. Because the distance education student is isolated in the learning environment, a degree of individualisation of learning is inherent in this setting.

-- The British Columbia case study points out that distance education creates an environment of student-controlled learning. This has both liberating and intimidating aspects.

-- The Australian university case study indicates it is now more possible to individualise distance programs than produce standardized products. Students can work at their own pace under a computer-managed instructional system and can have access to a wide variety of information.

-- The Turkish case study reports no individualised instruction, in that only one video machine and program were available.

39. The lack of human interaction in distance education is a major change in the teaching/learning environment. However, various new strides in technology are increasing the possibilities of some interaction in distance education.

-- The Australian university case study describes the use of teletutorials (teleconferencing by telephone) that allow group discussions and teleconferencing via satellite that provide interaction between staff and students.

-- The British Columbia case study documents similar advances that will help to compensate for the "missing link" in distance education.

40. The attitude of those involved in distance education varies with the situation.

-- The video system-aided instruction described in the Turkish case study has motivated the teachers and helped them transfer their learning from one curriculum area to another. Furthermore, the success of this in-service training programme has spread and created interest in teachers from other schools for the deaf. The parents have also become interested, and some attend similar training once a year.

-- The British Columbia case study indicates individual differences in the views of the learners. Some would prefer on-campus access to people and resources and less distraction at home. Others preferred the comfort and convenience of the distance setting away from the anxiety-laden classroom. A frequent comment by the distance education students was that they worked very hard for the course credit and that the courses were academically rigorous.

-- Instructors in the British Columbia case study reported excessive amounts of time in the preparation of distance education materials, but also satisfaction in the quality of the products.

C. Changes in Institutional Structures

41. The area of distance education is so new that no real changes in institutional structures have yet been documented to any significant level. However, certain cautions and suggestions should be noted in anticipation of rapid growth in this area.

i) Admissions policies should become more flexible with regard to distance education students. The typical student may lack certain academic qualifications, but usually compensates by increased interest and motivation.

ii) Distance education can meet the needs of those people who could profit the most from further education but who cannot afford to pay the educational fees usually charged for higher education. Special education services should be provided for such groups of people (e.g., new immigrants, the unemployed, the handicapped) through government and/or private sector subsidies.

iii) Competition among universities is keen, and universities are now faced with competition from the private sector. It is important that the cost-effectiveness of delivery systems be continuously addressed, and that learning systems be developed that are not wasteful of money or resources. Distance education programmes have higher development and lower delivery costs over time than on-campus courses. Institutions with similar goals should form co-operative networking units to keep costs low and avoid duplication of effort.

iv) Often educational establishments tend towards self-conservation and are often slow to adapt and respond to a changing environment. There is evidence of resistance to change which is due to feelings of job insecurity. This is found in the case studies.

CONCLUSION: TRENDS AND ISSUES

42. These case studies indicate that the impact of the new information technologies on education is at an initial stage. The general trend in the case studies is that the introduction of new technologies has implications for the contents of what is taught and for the psychological mechanisms in the teaching/learning environment. It is obvious that the new technologies often modify existing subject areas, they offer new ways of structuring and, indirectly they teach pupils and students new ways of thinking. Changes are occurring so rapidly that the state-of-the-art at the commencement of this study is not the same as that at the conclusion of it. However, some broad trends and issues do emerge.

43. Microcomputers have had a greater impact on the curricula of secondary education than on that of primary or higher education. The primary curriculum is more broadly based and therefore more difficult to alter, while higher education is more fragmented and decentralised and thereby more impervious to change.

44. Distance education is utilised most for higher and further education.

45. Students have to "learn to learn" and to learn to gain access to knowledge. But as learning is a social phenomenon and as people need contact with other people in order to learn some subjects, the need for a human interface has not diminished. Humans will continue to help each other to learn. But for education this will involve a change of thinking about education and the role of teachers. Change of thinking is the first challenge for the human interface. The new learning systems require self-learning and responsibility, and the role of the human interface is now more crucial than ever before. As more and more information is available in the home, as more people can be served without the need for attendance, the locus of learning will change in importance.

46. The control of the educational task is increasingly delivered into the hands of the student. The learning becomes student-controlled rather than teacher-controlled. This can have a liberating effect on the learner, offering a degree of freedom and power never before experienced in the educational

system, but it can also be intimidating, as one is thrown back on one's own resources.

47. The sources of financial support for computers and instructional programmes reflect ingenuity and special interest groups rather than any firm commitment to optimum utilisation. In too many cases, the large-scale purchase of hardware seems to have preceded any comprehensive planning of how to use it. Pressure from parents, community groups, and computer vendors may be having a larger influence on the purchase of equipment than actual needs of the students and teachers.

48. Lack of high quality and appropriate software is cited frequently as a stumbling block toward effective use of technology. The greatest satisfaction for courseware is found in districts/schools that have developed their own to match local needs and curriculum objectives. This, however, is costly and time-consuming. Nevertheless, considering the large amounts of expenditures for hardware, a redirection of financial allocations toward software development might be more cost-effective in the long run.

49. Training of teachers is being undertaken much more in-depth by school districts then by teacher education institutions. This may cause a problem in the future when school districts have completed training of all in-service teachers and assume that new teachers have received appropriate pre-service training.

50. Very little evaluation of the impact of NITs on the quality of instruction or student achievement has been conducted. Attention should be directed toward this aspect before any increase in funds toward programme development. Evaluation should focus on components of technology-related instruction that appear to be effective as well as those that appear to be unnecessary or detrimental to learning. Mechanisms for the dissemination of such information are vital.

51. Computer-related courses for both students and teachers lack attention to the societal implications of the NIT. Courses should include discussions of the human, ethical, political, and economic implications of the new information age.

52. The new information technologies have the potential to be the "great equalizer", reaching all levels of the population and individualising instruction appropriately. However, these case studies indicate we are very, very far from such a state. The ratio of computers to students is huge, and at present, special populations of students (e.g., gifted, disadvantaged) have the greatest access. Furthermore, the lack of good software limits the extent to which individualisation of instruction can actually occur.

53. While new technology-related courses are being added to the curriculum at nearly all levels, little is being done to modify the existing curriculum. Since there is just so much

time in the school day, attention should be given to reviewing the overall curriculum for obsolete, unnecessary, or irrelevant material that may be dropped and/or changed. At the same time, mechanisms for the development of more interdisciplinary courses should be developed.

54. At the present time, software tends to be directed at lower-level cognitive skills, such as drill and practice, enrichment, and remediation. Until computers address the development of higher-order reasoning skills and problem-solving, their effect will naturally be limited.

55. Production of original programs is expensive, and it is often more economical to purchase existing products. But there is a danger of losing natural experience if too many imported programs are used. That is a key question in this area as a whole: Do we import culture, when we import software?

56. The new information technologies do stimulate a great deal of interest and motivation, particularly at the elementary and secondary levels. Faculty in higher education appear somewhat more reserved than faculty at the lower levels, although students indicate strong interest at all levels.

57. Some educational commentators are questioning the degree to which the NITs will impact education, pointing to the investments made in closed circuit television and in programmed instruction in the 60s and 70s, and their failure to meet expectations. They suggest that the microcomputer may be just another "fad" or trend, which will lose its glamour in time. This view underestimates two important characteristics of the NIT. One is the pervasive influence of information technology throughout social and economic life and the resulting consequences for the relevancy of the content of the existing curriculum. The second is the interactive capability of the NIT, which previous audio-visual technology in schools has lacked.

58. The case studies demonstrate the major changes beginning to take place in the content and process of the curricula due to the introduction of information technology. It may result in the study of information technology as a subject in its own right, as an extension of existing computer studies work, or as a cross curricula activity. It influences the content of the syllabus for a specific subject to take account of changes induced by the application of information technology in that subject area -- the study of robotics in craft and technology courses is a case in point. The technology may influence the way in which a subject is taught. The use of information retrieval packages to handle census material encourages a different approach to historical analysis. This in turn emphasizes the need to introduce information handling and problem solving skills and to recognise their importance alongside basic numeracy and literacy. There is beginning to be a reappraisal of methodology, in particular the opportunities for individualised and independent forms of study.

59. Case study respondents disagree as to the future role of information technology in education. Some view the computer as just another learning tool, one that will be important for instruction insofar as it facilitates teaching and learning. Perhaps the most exciting possibility that information technology holds for education is in making available more flexible opportunities for learning best suited to the individual's needs and circumstances. The new information technology will be able to help potential students find out what opportunities are available; provide new ways of delivering learning materials and in formats that allow much greater interactivity between the student and those materials; provide new ways of communication between the student and tutor and other students; make possible new techniques for helping students and teachers monitor progress. These opportunities are all based upon the use of information technology that will be found increasingly in the home. The information technology will support a shift of power away from the teacher towards the learner and make possible a considerable improvement in the quality of educational provision and opportunity. Others believe that the use of the computer can make true individualisation of instruction a reality. And others believe that educators must now rethink the role of the teacher within a new structure of the classroom, one which fully incorporates the computer into instruction while the teacher guides and manages more than teaches. In any case, until software address the development of higher-order thinking and reasoning skills as well as the interactive nature of learning, the computer will remain just another learning tool and the teacher will remain the provider of instruction.

60. As new devices enter to change the learning environment, such as computer, television and teleconferencing, so the interface between teacher and student is changed. If technological changes take place more quickly than changes in our ability to understand them, this problem will need to be addressed more fully if educators are to keep pace with our present age of rapid technological expansion. The effect of well-applied technology will be to improve instruction, but the effect of improved instruction is almost always to put greater demands on the creative teacher.

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THE IMPACT OF THE NEW INFORMATION TECHNOLOGIES ON LEARNING PROCESSES IN FORMAL EDUCATION

The attached document, prepared by the Secretariat, will serve as a background report for Working Group 2.

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"Organisation is a universal property of organic matter. Life as we understand it is only an evolved form of that organisation." (H. Reeves, 1981)

"Human reason is a product of biological organisation, a refined, superior product of course, but ultimately just one product like any other". (J. Piaget, 1975)

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INTRODUCTION

> "The nature of the new information technologies is not the electronics, but the formal language, the rules and methods that are set to present reality to computers and the programmes utilised to make them function. It is this invisible aspect of the technologies that makes them important in different contexts."
> (I. Ruoppila, 1983)
>
> "Culture is being lost from view in a welter of products, in an avalanche of signs, in senseless quantity." (M. Kundera, 1984)

1. This report covers one of the areas under investigation in the CERI project on "Education and New Information Technologies" [CERI/CD/(81)15], as it was approved by the CERI Governing Board in November 1981. Its objective is to clarify the main issues and problems on the impact of the new information technologies (NIT) on learning processes in formal education. While anchored on cognitive grounds, this report addresses a readership other than that of specialists in the cognitive sciences. It addresses educational experts, practitioners and administrators, who are increasingly involved in making decisions as to the planning of investments, the development of curricula and of innovative teaching/learning strategies in a technologically modified environment. This "educational" slant affects the whole of the report, it biases the selection of "cognitive" issues, it influences the terminology used, more familiar to educators.

2. As its title indicates, this report is concerned with learning processes in the school. Its data basis covers information gathered in research and educational experimentation on the development of learning that is, or might be, relevant to the world of schools, in both primary and secondary education. Its mandate is not to propose a synthesis of all the available literature in the area but, less ambitiously, to clarify the main constituents in the current debate on learning and the new information technologies on the basis of an indicative body of experimental results.

3. This "down to earth" approach has given a concrete rather than speculative grounds to the analysis. It has also narrowed the discussions to the consideration of those issues and problems which happen to have been the object of investigation. It will be easy for the reader to spot the topics that, although important to education agendas, receive here only a cursory treatment or are altogether absent from the text. Such omissions should not

be taken as indicating possible priority shifts in future education agendas. They merely denote that the place of these issues in the "technological" programmes of work is, just for the time being, peripheral.

4. In addition to narrowing the selection of topics, this report's preoccupation of being concrete rather than speculative has also resulted in a much narrower definition of the technologies considered. The bulk of data available on "information technologies" and learning processes relate almost exclusively to computers and especially to micro or mini computers. This is the current bias in the "technological" working agendas. This is, unavoidably, also a bias of this report.

5. On more conceptual grounds, a further characteristic of the analysis presented here is to rest on a central assumption on the nature of learning and of the forces and factors shaping it. The assumption says that learning does not take place in a vacuum, that the process of learning depends on more than just the nature of what is to be learned and the ability of the learner to perform. When absorbing new concepts or mastering unfamiliar skills any individual is also reacting to a multitude of other actors and factors -- visible or invisible, silent or vocal -- all influencing, manipulating, encouraging, discouraging, hampering or fostering the growth of the capital of knowledge in the learner.

6. Any analysis of learning processes, any intervention intended to develop or modify them by altering their human and technological environment, cannot but acknowledge the existence of these "other" active agents. As well as to the learners, it is to these active agents that the processes are adjusted, it is with them -- or against them -- that the learning can possibly be changed, by way of the new information technologies or otherwise. These agents are not difficult to recognise: they influence the life-long learning whereby the child grows into an adult, whereby individual life-patterns are constructed for work, leisure, family and social life, until the end. These agents are as tangible as the family, the school, the peer group, the work place, or as vaguely perceivable as the networks of powers and concerns surfacing through cultural and educational policies, through the information channels or more generally, which shape the life conditions (social, economic and political) whereby an individual can learn. In short, and this is what it is important to underline here, learning processes unfold to the learner under a number of influences, from within and from without, conditioning to various degrees what is learned, how and to what purpose.

7. The new information technologies do not eliminate the dependence of actual learning on factors other than the learner's aptitude to learn. But the question deserves to be asked whether they can shuffle their relative influence, whether they can change the patterns of influences, whether they can introduce new conditioners. The issue is therefore raised in this report of whether, together with any specific effect on the learning aptitudes as such, the new information technologies, by acting as a vehicle of influence, or by generating some of their own, can change what is learned, how and to what purpose.

8. As a response to the perceived potential influence of the new information technologies on learning, the current debate has sometimes taken on cultural and philosophical overtones, exemplified by a much-voiced concern: will the new "technological" power released by man to his benefit

lose control and turn against him? In terms of learning processes, this "existential" pre-occupation questions the degree of distortion introduced by the technologies in the representation of the world or of the man-built knowledge transmitted by them on to the learner. In each case the attention is called on the consequences for the learner of emphasizing the growth of logical patterns, of privileging the acquisition of cognitive skills, that risk reflecting more the specific nature of the electronics underneath than the overall possibilities of the human brain. In short, by defining themselves as alternative gateways to the acquisition of knowledge and skills, the technologies are presenting mankind with the possibility of new sources of influence on what is learned, how and to what purpose.

9. Perhaps the largest potential held by the new information technologies is in terms of quantity: they can increase beyond imagination the amount of information accessible to the ordinary people, by increasing the possibilities of storage, transmission, diffusion and retrieval. Perhaps the single most important challenge this creates for learning is in terms of quality: how can any single citizen learn to manage this new possibility? Our society is already information rich. Already learning processes are conditioned by information flooding the homes, the workplace, the school, the community. What to expect if the amount of information increases yet further, if its degree of coherence, already small, decreases even further. No doubt such issues will fuel a number of policy debates in the future, in a variety of policy sectors.

10. In education, this debate on the quality of learning can be seen as touching directly upon two aspects of its institutional mandate: the chronological organisation of learning -- essentially a question of curriculum -- and its management on pedagogical grounds.

11. In terms of timing, some of the (interrelated) questions raised more often in the curriculum area concern its targetting to the age of the pupil, its sequential organisation and the speed at which specific knowledge and skills can be acquired. Most of the curricula, especially in basic education, are designed on the basis of some developmental assumptions on the cognitive abilities of the pupil: certain notions and certain skills -- e.g. concrete or formal -- cannot be acquired before a certain age. Another widespread assumption sees learning as essentially a cumulative process where notions and skills are acquired through a carefully balanced sequence of steps from simple to complex. To what extent will these assumptions survive the impact of the technologies, to what extent will they be invalidated, transformed, expanded by them? Section I of this report will discuss in some detail some of the answers which start emerging, primarily from the area of research on cognitive psychology and artificial intelligence. The important point to anticipate here is that far from being theoretical and beside their vested interest (the survival of the institution in its current form is one of the implicit stakes to this debate) questions such as these point to possibilities that are real and already visible in a number of specific educational instances.

12. Next to concerns more directly "cognitive", the debate in education develops along lines with a more specific institutional bearing. The new information technologies, by increasing access to information and by changing the definition of knowledge and skills, can have an impact on the definition of disciplines as such, and hence, together with the (possible) impact on the cognitive performance of the pupils, can alter the curricular boundaries

between established courses, even between levels of schooling. More importantly, they can change the pedagogical pillars on which the institution of education stands.

13. In terms of teaching/learning styles, the presence of the new information technologies can facilitate a shift from passive to participatory learning, from learning by "swallowing" to learning through personal discovery, from group (class) activity to independent learning. The learning strategies taught in schools can also change. The access to stored information together with its multiplication can shift the emphasis from memorising to reasoning, from the acquisition of fragmented to that of holistic knowledge, e.g. through simulation techniques. In short, as a recent report puts it, "computing as a resource may give the teacher back his proper function, of showing the pupil how to do without him". (GIDES, 1983)

14. Section II of this report will discuss in some detail some of the conditions and consequences of the introduction of the new information technologies in classroom learning. We will then see the importance to this debate of interrelated concepts such as threshold conditions of human and material resources under which no impact on learning can be expected, and processes of evaluation of the prerequisites to obtain desired effects, as distinguished from those producing no effect (for whatever investment in resources) or, worse, undesirable effects on learning. In this same section we will discuss how questions related to the organisation of learning via the new information technologies and its consequences on the functioning of the institution of education, affect issues central to the educational debates of the past decades, namely those of the equality of the pupils. Finally, Section III draws some conclusions on the possible working agendas for the future.

15. It is difficult to enter the core of this report without the feeling of having to face more questions than any single report can possibly respond to. In fact the answers, if they exist at all, will not all be found in the pages that follow. Yet the question had to be raised of the meaning of analysing the impact of the technologies on learning processes in formal education without making reference to the real life context in which the object of this report evolves, within which decision-makers have to provide responses of a policy as well as political nature. The vagaries of this introduction illustrate how unrealistic this would be. This section shows the complexity of the apparently academic exercise at hand, illustrates the multifaceted deeper nature of the processes under scrutiny, the variety of expertise called upon to provide solutions, the scores of vested interests underneath, the emotional connotation of some of the issues debated.

16. Against this background, the report can now proceed to a narrower enquiry of manageable proportions, by focussing more specifically and concretely on those, among the issues mentioned here, which belong to the specific agendas of research, pedagogy and education. The broader considerations of these first pages will accompany the analysis as a counterpoint . They will be called again to the fore in the conclusive section to give body to the considerations developed there on the likely trends for the future, on the likely priorities in research, pedagogy and, especially, education.

Section I

LEARNING PROCESSES

> "Using computers (could) challenge current beliefs about who can understand what and at what age... Using computers (could) question standard assumptions in developmental psychology and in the psychology of aptitudes and attitudes" (S. Papert, 1980)

> "One day the computer broke down because she had no children to teach. The children came back and put a bandage on her screen. The computer felt better and began teaching again. The class lived happily every after." (A primary school pupil, USA, Collins, 1983)

17. With this section we enter the core of the debate on the impact of the new information technologies on learning processes in formal education. Those in charge of designing, planning and managing educational programmes put forward specific questions as to if, when and in what conditions, the NIT are likely to have an impact on the learning processes induced in the various population groups present in the school. They need to know what the changes are, if any, in the "quality" of the learning taking place in the modified conditions. They ask whether the array of abilities learned or knowledge acquired via the NIT differ in any considerable way from what is obtained within "traditional" educational environments. In particular, they are concerned with the possible changes that the NIT can introduce in the organisation, structure and management of the formal educational system with respect to the age structure of their population and the articulation of the various disciplines and courses of study.

18. Questions of this kind are both pertinent and unequivocal. This and the subsequent sections, attempt to answer them, by taking the analysis from its starting point, the cognitive processes, and developing it by considering the possible pedagogical applications of the new knowledge and understanding on learning emerging from research and experimentation work. In the next section, the analysis will be developed further by considering the ways whereby the most promising pedagogical approaches could be brought to bear on current educational practices in view of a large scale introduction of the NIT into schools.

19. To establish an analytical structure for a discussion on learning

processes and the NIT in formal education, means to operate on a selection of issues which, possibly contrary to expectations, is, for the time being, rather limited. Although each large and complex in itself, the three areas do not share a large number of issues. The relationship between learning as a set of psychological processes and learning as the pedagogical management of them has been historically tenuous. Of the large ground covered by each, there is little that could be identified as common to both. The part of it which is also relevant to the NIT, whose bearing on the previous two is only just developing, can be but smaller still.

20. Therefore, more than the result of a reasoned choice among likely alternatives, the analytical structure proposed in this section is rather one of convenience. This structure does not reflect the existence of a large enough body of data (not produced as yet) nor does it emerge from sound theoretical models as to their possible significance (still being developed). If this section has a value, it is of a highly pragmatic kind. It develops a tentative analytical framework which allows a reasonable discussion of the issues at stake without pushing the speculation too far. In addition, it allows a discussion of typically theoretical and experimental issues on grounds familiar to those for whom this report is ultimately written: those in charge of schools and of educational policies.

21. For these people, asking questions on the possible impact of the NIT on learning processes in formal education means essentially to assess its implications in terms of three broad issues, each related in important ways to the organisation of the institutional system. The first is the chronological organisation of learning. In which ways do the NIT alter the speed at which pupils usually learn? How do they change the age targetting of institutionalised learning? What is their impact on its traditionally sequential organisation? The second is the contextual organisation of learning. As in other instances, school learning involves interacting with humans as well as with learning tools. In which ways do the NIT alter such a context of learning? With what effects? What if the NIT replace the teachers? What if they limit the social interactions with the peer group? How are the technologies percieved by the young learners? The third is the topical organisation of learning. How could the knowledge and skills taught at school be modified by the NIT? What becomes of the basic skills? What new skills have to be learned? What cognitive prerequisites are needed by what new learning? What is the transfer value, what are its cognitive consequences?

THE TIME DIMENSION OF LEARNING

22. A first topic to consider under this heading is model-free, as it were. In a variety of circumstances, at different levels of schooling and in different learning situations, it has been observed that, when learning is computer-based, the learning itself is accelerated. A typical finding says that students have been found to learn more, retain more or learn the same amount faster using computers (e.g. Bracey, 1982).

23. Besides (rare) quantitative confirmations by bodies such as the California Testing Service, the wealth of evidence put forward to sustain the claim, remains unmatched by the reliability and validity of the observations.

What exist most in this area are teachers' reports. When computers are introduced in classroom teaching, it is not unusual to have reports of pupils covering the year curriculum in much less time, to the extent of creating some perturbation in the organisation of the classroom. A Canadian teacher comments on the situation: "Some of the bright children are now wanting time alone on the machine. Maybe they are looking to escape into it and ignore other things.. I am giving them some lone time but they are having to come back and teach the rest of the group. I feel that I must stop them from getting too far ahead, for then, they tend to say that the other kids do not understand. This way they are bringing the group along with them" (Burnett et al., 1983)

24. At times the gain in time is expressed by a general feeling of "easiness". Examples could be found at the intermediate schooling levels, where, for instance, a teacher has reported on a LOGO experience, that "using co-ordinates on the computer made the learning of latitude and longitude in geography easy" (Burnet et al., 1983). From the same report, a grade 6/7 teacher writes: "I have taught all the Grades 6 geometry and gone beyond the curriculum to the Grade 8 level of angles. When I was teaching a lesson on lines, points and vertices the children said they already knew it. This is a result of working with the computer... I feel my class is ready for recursion in understanding although they did not have the maths concepts yet".

25. At other times, the findings are of a more concrete nature. A recent report, for instance, states that at the post-secondary level, "in every study in which computer-based instruction substituted for conventional teaching (either for a unit, a module, or for an entire course), the computer did its job quickly -- on average in about two-thirds the time required by conventional methods. It is clear that the computer can function satisfactorily in college courses and at the same time reduce time spent in instruction". (Kulik et al, 1980)

26. Although far from scientific soundness, the anecdotal evidence is particularly compelling in the case of remedial learning. In a number of cases, the low achievers, the school failures have been observed to learn, at least in the basic skills, in a relatively short time where years of traditional teaching/learning situations had failed to produce any noticeable results (e.g. Naymark, 1983).

27. Faced with such an increasingly suggestive body of evidence, a first, rather basic, question arises as to its possible meaning: do the NIT produce qualitatively different learning processes or do they just change the persepctive with which we observe what are essentially the same processes and mechanisms as in "machine-free" learning environments? Do the NIT sollicit the development of new brain functions or are they merely eliciting a different organisation of otherwise familiar human functions?

28. It can very well be, for instance, that the NIT shorten the time spent to learn simply by way of rationalising the learning situation. There is no doubt, for instance, that most ordinary learning processes in the classroom are rather wasteful in terms of time. One could easily imagine how the NIT could hasten them by eliminating hollow periods, by keeping the learner active and motivated, by presenting the information in ways that are easier to assimilate. It can also be that the new technologies bring to the awareness of the learner elements which are important to the learning and which would

otherwise go unnoticed. In the words of a French author, describing the possible reasons at the root of observed performances in learning Logo, "the computer's capabilities are likely to modify the pattern of child development, by speeding up some of the stages in it. This precociousness is probably associated with a combination of beneficial ways in which the computer can help certain learning processes along. Those beneficial aspects are interactiveness, the learner's being continually stimulated, instant self-correction, independence, creativity, and the learner's intensely active involvement" (Naymark, 1983). Similar questions are advocated in the other major areas where the NIT have been observed to correlate with surprising results.

29. Next to the impact on the time spent on learning, another strand of similarity among observations concerns the onset of certain learning processes, particularly on the apparent modifications of the age at which notions or skills can be learned. The work of Piaget or Bruner, to mention some major names, has demonstrated convincingly that cognitive development takes place in predetermined sequences, holding two main characteristics: their relative positioning is irreversible; furthermore, they mark a progressive detachment of the learner from the concrete environment towards an increased reliance on "inner" mental structures. Among the researchers who have applied such understanding to "learning by computers", the name of Seymour Papert has come to acquire a major prominence, particularly in relation to the LOGO system, in itself an application of the Piagetian model of concept formation in children during their concrete operational stage.

30. Developed at first in laboratory conditions, LOGO has acquired of late a tremendous visibility of almost mythical proportions. Its reputation is built not only on what it seems to confirm of the established models of cognitive development, but also, and perhaps more importantly, on what it seems to refute or qualify in them. LOGO has been among the first computer-based learning systems to produce additional ammunition for those who, on the basis of non-computer based research work, have long cast doubts as to some central hypothesis of established models of cognitive development. The major debate worth mentioning here is that of the alleged inability of young children to perform at formal levels of thought. Many educators have concluded from Piaget's work that children lack the conceptual structures needed to operate on abstract notions, an ability which is not supposed to develop until the mid-teens. In the recent years the evidence has multiplied on the cognitive age-marking introduced by Piaget, being influenced, and possibly changed, by factors other than cognitive, of social and cultural nature (e.g. Doise and Mugny, 1981). This newly acquired understanding has not had much influence in modifying the original belief, which has been further strengthened by findings such as those from clinical research showing correlations between cognitive stages and physiological phases of neuronal growth in children (e.g. Toepfer, 1982).

31. The LOGO-based experience has since opened the gates to a multitude of research work throwing more systematic doubts on this central hypothesis. In the words of Seymour Papert, the Turtle, the main tool of communication between the child and the computer in the LOGO learning system, makes it possible to uncover the unexpected: "My goals are education, not just understanding. So, in my own thinking I have placed a greater emphasis on two dimensions implicit but not elaborated in Piaget's own work: an interest in intellectual structures that could develop as opposed to those that actually

at present do develop in the child, and the design of learning environments that are resonant with them. The Turtle can be used to illustrate both of these interests: first, the identification of a powerful set of mathematical ideas that we do not presume to be represented, at least not in a developed form, in children; second, the creation of a transitional object, the Turtle, that can exist in the child's environment and make contact with the ideas." (S. Papert, 1980)

32. To remain in the area of mathematics learning, it is worth adding to Papert's the conclusions drawn from a recent report summarising the results of a number of researches, not necessarily computer-based. "Children", the report says, "have significant conceptual understanding of mathematics concepts at much earlier ages than had been believed previously. Early understanding of these concepts is incomplete and largely implicit, but it is clearly not totally lacking, which means that instruction should be designed to capitalise on important conceptual building blocks that children have, rather than assuming that they have no cognitive basis for developing understanding of important abstract principles." (FBPCS, 1983)

33. The evidence is suggestive and multiplying. In a number of countries systematic investigations in this area are currently being carried out. They show the enthusiasm, sometimes the euphory, generated by the promises implicit in the earlier findings. Yet a word of caution has to be said, as the investigations are not always as scientifically sound as they might appear, as sometimes the conclusions might be dictated by the expectations more than by an objective assessment of the balance between what is and what one would like it to be.

34. Surveying a number of French experiments, a recent report describes the situation in the same critical terms as could be applied to other national situations. "The material available at present is not at all rigorous, either as to conditions or still less as to results achieved, so it only warrants some initiative and rather broad comments. Every investigation concerned with younger children emphasizes the ability to look ahead that is involved in programming, because it implies being able to imagine beforehand what the outcome will be of the successive operations necessary to achieve the intended results. Children do look ahead to some extent, but their strategies (empirical, analytical...) can vary and achievements are mixed... Underlying these experiments, of which there are more and more, is a major pedagogical insight: a child's heuristic activity, brought on by having him/her work on this kind of intuitive geometry and logic, is likely to transfer to other, more academic activities... early reading (by about age four) can be taught by a technique that has already been shown to work relying on the stimulus provided by the interactiveness of the computer. The findings of research along these lines will be worth close attention...

35. For older children, the committee assessing the computer option in the lycées has made various comments on learning to program. Unguided, spontaneous programming (which children can do because a certain number of algorithms can be programmed very quickly) results in programs whose complexity reflects whatever level of capability the child has reached for reasoning in the abstract. A child who can grasp a purely sequential process will have no difficulty in writing a set of "do" and "if" instructions. One who can grasp iteration will have no difficulty in including loops... There is probably a need to check whether any attempt is or is not being made to

inculcate knowledge via computing beyong the pupils' usual level."
(Naymark, 1983)

36. It is not the objective of this report to assess the scientific merits of one or the other line of research on the sequential organisation of learning. For the purpose of this report -- to clarify what might be the possible impact of the NIT on learning -- the evidence, as well as the doubts, reported above stress a central meaning of the results obtained: the great potential of the NIT for understanding learning processes.

37. Some of the observations and results discussed here, and most of those analysed subsequently in this text, indicate the double role of the NIT vis-à-vis learning processes: as modifiers of the processes and as tools for understanding them. The introduction of the NIT in the learning environment leads (although not systematically and according to modalities still largely unknown) to changed performances of the learners. The observed changes indicate some modification of the learning processes underneath and/or of their cognitive and motivational determinants. This, in itself, is conducive to better understanding of the processes.

38. But the impact of the NIT on learning goes farther. By providing the technological support for increasing the flexibility and richness of the learning environment in terms of information, exploration and discovery, and, most of all, by making data collection and analysis fast and undemanding, it qualifies as an important tool of research on the effects it produces. This double impact of the NIT on learning is an important issue to underline at this point of the analysis, as it will accompany the reader throughout this report. The contention is supported by evidence in this section and constitutes one of the conceptual pillars of the subsequent one, when analysing the impact of NIT on pedagogy and education. It constitutes also one of the central considerations of the conclusive section on priorities for the future.

THE CONTEXT OF LEARNING

39. In the quest for what makes learning possible, few would deny the important role played by contextual factors, such as the presence of a "tutor" or the interaction with the peer group, or with specific technological supports. Yet in the study of learning by the NIT, this area of enquiry has remained largely neglected.

40. The few fragments of evidence available tend to cluster around topics such as the merit of individual vs. group learning, or the personal reaction of the young to the computer. Some North American studies report favourably on the effective/emotional outcomes of "learning with computers" or speculate about "useful social effects when co-operation is supported rather than competition" (Crossley, 1983)

41. Some Scandinavian experiences from the upper grades of the compulsory school, from general secondary schools and from upper vocational institutions, show that there are pupils, although admittedly mostly boys, who are highly motivated to learn by way of the NIT and ready to use their time and energy to

find out ways to develop themselves in the new skills (Ruoppila, 1983). These observations are not paralleled by any deep understanding on the resulting cognitive and social development of the students, although, at least at face value, they seem to indicate an improved level of social interaction and a transfer of benefits to the advantage of students' school work in general. An official publication on the evaluation of the Swedish project PRINCESS (aiming at studying the feasibility and desirability of learning by computers in schools) is explicit on this point: "The various computer aids used have been found to improve the quality of teaching and learning... Project work is made easier by computer aids. It was also found that computer aids could be usefully employed in group work involving two or three students. Word processing was the only connection in which students did better working individually. Co-operation between students improved in most cases." (CLEA, 1983)

42. But even word processors do not necessarily lead to isolated learning, if only the organisation of the learning environment changes. A small-scale Canadian study, for instance, has found that "when children had access to their own private terminal there would be little interaction about their writing tasks because they would be so eager to work on their own projects." (Kane, 1983). This apparent confirmation of the Swedish findings on the use of word processors is, however, confuted by findings such as those of another Canadian study on the effects of a second monitor standing facing the pupils at the head of the class. This second monitor was found to generate intense socialisation between the users of the simple word processing facilities and their classmates. "Perhaps", the author comments, "having a limited number of terminals for word processing use would be a blessing in disguise..." (Logan, et al. 1983).

43. Other observations of Canadian classrooms confirm that "independent" learning with computers is not necessarily synonymous with "isolated" learning: "Observations in classrooms with microcomputers available for regular use indicates that the keyboard and screen become the focus of small group relationships among students who are intent on solving problems. This phenomenon is contrary to earlier predictions, based on experience with library carrels and with senior students intent on academic studies." (Crossley, 1983)

44. If the pupils and students like the computer there must be a reason. Very little is known on this subject besides anecdotal personal reports. Some interesting insight comes from sparse observations showing that whatever their determinants, the reactions could be, for instance, class-dependent. A survey of experiments in the French primary schools indicates: "original investigations into childrens' perceptions of the computer show that drawings by children from comfortably-off backgrounds are fairly stable over a full year spent using the computer, while drawings by less privileged children evolve from an anthropormorphic picture of the machine (e.g. spiderman etc.) towards a more instrumental one." (Naymark, 1983). Children's reactions can also depend on the degree of familiarity with the computers: the more familiar the child the more realistic his/her representation of the computer's possibilities (INRP, 1981).

45. Observations of older pupils in remedial education suggest that computers might have specific "motivational" virtues: "in a context of all-round failure at school, computing as an activity strongly stimulates and

motivates pupils. The positive reinforcements, the ability to check out an abstract activity immediately, the scope for creativity, the ability to reverse the traditional teaching situation by instructing the computer, all help the pupils to get out of their anti-school attitude and build up their confidence in themselves." (Naymark, 1983).

46. Similar positive reactions to the computer are reported by a Canadian teacher: "Watching many learners use courseware leads increasingly to the belief that the learner learns more and more happily, when he or she has control over his or her own objectives and methods of learning" (Godfrey and Sterling, 1982). Requested to identify the most satisfying use of microcomputers in their classes, 74 per cent of Manitoba teachers indicated: "motivation and interest of the students" (M.T.S., 1983). Other positive attitudes are reported anecdotally from Scandinavian countries where the introduction of the computer in the classroom has often generated "clear positive effects on teacher-pupil relationships, due to the enthusiastic feeling and common interest which make the interaction democratic" (Ruoppila, 1983).

47. However patchy, the above data indicate rather clearly how interactional and organisational variables are increasingly appearing as major factors in determining the kind of learning taking place via the NIT, although, again, the specific modalities of the impact are not as clear. The subsequent section discusses further the role played by the variables more specifically linked to the management of the school. What could be underlined here as a partial conclusion is the growing awareness of the contextual organisation of learning, as being an area of enquiry as important as it is uncharted. As modifiers of the social environment of learning and of its support structures, the NIT can safely be expected to influence learning. Research and experimentation work is needed to ascertain the kind of impact thus produced, the kind of changes introduced on learning, the kind of learners likely to be affected more than others and in which ways.

THE CONTENT OF LEARNING

48. Of the little information that exists on the impact of the NIT on learning processes, this is the area where most of it can be found. This polarisation of research efforts reflects the central mandate of education, namely the equipping of the young with the basic knowledge and skills to lead a socially integrated adult life.

49. Within this general context, the bulk of research generated so far has stemmed from a more specific concern: the acquisition of basic skills. Two main trends can be identified in this area: one aims at clarifying the impact of the NIT on "old" basic skills such as reading, writing and numeracy; the other aims at analysing the emergence of possible "new" basic skills, more directly linked to the cognitive demands and possibilities opened up by the new technologies. The debate on the cognitive value of computer programming skills is central to the latter trend. In both cases, strict cognitive concerns are parelleled by an equally strong emphasis on the NIT as a tool to improve the efficiency of the educational system.

Reading

50. In the realm of learning to read, the NIT could influence the process in a variety of ways: they can operate on the learning environment, on the motivation of the learners and their tutors. They can also -- and these are the issues on which most of the evidence is based -- influence the process by introducing new content materials and new technical supports, as well as by making different teaching/learning approaches possible.

51. The issue of reading skills as content-bound is an old one to which a number of analyses have been devoted. Some of them have been articulated in terms of quality and familiarity of the schools' reading materials. The contribution of the NIT to the quality issue is far from clear. Whatever the diagnosis of the merits of current instructional material, the question remains unanswered as to what beneficial effect could be expected by the NIT. A priori, there is no reason to suppose "that the pedagogical acumen of people who write computer software is going to be any greater than that of people who write paper-and-pencil workbooks" (Anderson, 1983). In that, the NIT do not introduce new terms to the debate, but re-propose under a different form, such as software development and authorship strategies, concerns already established.

52. The issue of familiarity of school reading, on the contrary, qualifies as highly relevant and specific to the possible influence of the NIT on reading. A central question to the acquisition of reading skills is whether any suitable materials of instruction can be used to teach skills of reading and writing. The developments observed in most Member countries over the last decades seem to provide a positive answer to it. In most schools the material used to teach to read have not ceased to multiply and diversify. Today's pupils learn to read from a large variety of textbooks, mimeographed sheets, games and other instructional tools. Without any doubt these developments are a plausible solution to some of the problems at the origin of recent and less recent school changes. Decentralisation, autonomy, multiculturalism, alignment with real-life concerns, have all led to increased curriculum differentiation across schools, as well as increased variety across classes.

53. The extent to which these changes are also solutions to the problem of the quality of reading skills is much less clear. A recent line of research suggests strongly that the proliferation of different materials, by exposing the learners to an increased amount of unfamiliarity, can severely offset the benefits gained from their quality (Hirsch, 1983). The quality of a text -- the model claims -- makes a difference in comprehension only when the learner is familiar with its subject matter. Familiar reading material produces the expected effects: good style is all the more helpful to comprehension when the content is difficult. Exposure to unfamiliar material, however, tends to produce reading performances that are counterintuitive. Here good style contributes little to the quality of reading.

54. Subject to confirmation by other researches, the role of content familiarity on the acquisition of reading skills could well be a crucial one in the area of the NIT. As noted before, perhaps the largest potential of the NIT is for the quantity and variety of information they give access to. To what extent this new power could turn into a Pandora's box for the acquisition of basic skills such as reading, is a question deserving careful scrutiny.

55. The issue of reading skills as support-bound is also one that qualifies for close analysis. The intuitive idea of an unavoidable specific influence of technologies such as the computer on the acquisition of reading skills begins to be substantiated by clinical research showing how, when reading from a visual display screen, the brain produces wave patterns different from those corresponding to reading from a printed text (Logan et al., 1983). Some research is also investigating the possible differential effect of learning by computer on various related subcomponents of reading skills such as word recognition (the speed of which seems to increase) and word comprehension (the level of which seems on the contrary to decrease)(Collins, 1982).

56. Finally, another area worth mentioning as to the possible impact of the NIT relates to the teaching/learning strategies whereby reading is taught in schools. Despite the considerable progress made in related fields such as in linguistics, the approach to teaching reading has undergone little change over the decades. It was, and still is, essentially phonetic. Children are taught to learn to read by matching written symbols to sounds. Over the years, and depending on the countries, letter recognition has been replaced by syllable or word recognition as a couterpart to sound. But the relationship has remained phonetic. Other approaches through grammar or meanings have remained, for good or worse, largely absent from the classrooms. To the extent that computers have no voices (in itself a temporary condition) such approaches might be replaced by others, the effects of which on the acquisition of the skill are still uncharted.

57. If the above list of issues might look like a dog's dinner to some, the impression would be essentially correct. If little is known on the impact of the NIT on the acquisition of reading skills, this is also because little is known as to the deep nature of reading, which in itself makes it hard to develop an analytical structure to discuss possible influences on it. At best, reading is only "a partially observable, partially decomposable process, best conceived as a system of interacting component processes" (Anderson, 1983) which are far from being understood. Perhaps the most important impact of the NIT could be expected precisely at this level, to make reading understood. In this context, lines of research on reading difficulties, on the diagnosis of reading strategies and errors are possibly one of the main priorities in this area.

Writing

58. That writing can be decomposed in a sequence of stages is an assumption shared by most of those who teach to write. What they would be less ready to accept is what is more important in assessing the skill level acquired: the quality of the final product or of the process producing it.

59. As for reading, the study of what makes writing possible, and at what level, has undergone several developments over the years. The shift of attention from the products to the process is the latest one brought about by empirical studies of writers' behaviour and parallel progress in the understanding of the cognitive processes underneath. While it is not within the aims and possibilities of this report to discuss at any length the problems encountered or the results achieved in this field, it is worth emphasising here one of the conclusions of an expert: "All children can learn to write... Young children are able, given support and guidance... to adapt

the powerful language learning strategies they employ in learning to speak to the process of learning to write" (Gundlach, 1983)

60. If we draw the parallel to language acquisition in this section on writing, it is less to support any school of thought claiming a link between the two than to underline the specific role that the NIT could play in learning to write. In learning to speak, the child has no other mechanical skills to master than the sensory motor control of his own organs. Writing with pencil and paper is much more taxing. The sensory motor control of arm and hand drains much of the resources of the child. How to concentrate on ideas, how to focus on structured paragraphs, how to retain the thread of a story, when so much effort is required just to draw letters and words.

61. It is in this area, the writing skills of beginners, that the NIT are already having a visible impact on learning, by way of the word processor, which eliminates most of the mechanics involved in writing. The impact on the speed at which the skill is mastered, in terms of syntactic and grammatical correctness is particularly visible with those children having difficulties via the normal practice and with the youngest among them.

62. Although much needs still to be done to understand the reasons why the process is facilitated by the word processor, why writing as problem solving is improved, it is interesting to note the wealth of anecdotal evidence from the users themselves. In primary as well as secondary education, pupils report why word processors are better. With them, they say, there is less concern about making mistakes as corrections are easy (and can be made away from teachers' eyes). The text looks better, and this makes it easier to fix errors and ideas. Typing doesn't hurt the hand like writing does. (e.g. Naymark, 1983, Collins 1982).

63. Such physical and psychological benefits are claimed by older writers as well. As a recent report puts it: "The psychological inhibitions of writing and rewriting letters or essays... almost disappear. Even spelling corrections become a form of 'debugging' rather than fault finding with penalties. There is enough empirical evidence in classrooms as well as in the offices of business and industry to illustrate the 'freeing-up' of the thought processes that takes place as a result of the relative freedom from the mechanics of writing and/or typing." (Crossley, 1983)

64. Having been freed from its dullest demands, writing can be learned in different ways; for instance, by experimenting different strategies for composing essays. This is the objective of newly produced software such as the Essay Outliner, produced by Canadian teachers, whereby the students can either outline a sequence of topics, then expand them to create the essay or, alternatively, adopt a wholistic approach from which to extract the elements of the structure or outline. The production of such software stresses the importance of providing writing alternatives especially in the primary and early secondary years of school when the creativity of all students should be fostered, while skills are taught.

65. But dinners, even dogs' dinners, do not usually come for free. As with reading, not much systematic knowledge exists as to the cognitive processes involved in writing. Although not many "warning signs" have shown up as yet, the risk that the NIT provoke side effects less positive than those reported above remains. Here, as for reading, as progresses are made in research, the

awareness grows on the complexity of skills subsumed under the generic label of "writing", hence of the multiplication of the possible side effects induceable by the technologies. The sharp differences ascertained between novices and expert writers are only one of the new avenues of investigations in this area. The difference in the skills underlying the writing of short, as opposed to long, texts is another.

66. As with reading, the contribution of the NIT to writing can be expected at different levels. They can facilitate the acquisition of the skills as we know them. By the same token they can have other unforeseen effects on what is still unknown. Perhaps, even more importantly, they can be used to understand the processes themselves, by reconstructing the strategies developed by the writers to write, to correct, to revise.

Numeracy

67. A recent report from the US (Davis, 1983) describes the situation in the field of mathematics learning, which could be easily generalised to other countries:

- A very large number of students can learn considerably more mathematics than they typically do at present;
- The discrepancy is particularly pronounced in the case of mathematically gifted students;
- Many students are in fact learning far less than they are believed to be learning.

68. In order to tentatively assess the impact of the NIT in this area, it is useful to analyse some of the reasons believed to be at the origin of the outcomes observed. Some trace the roots of the problems back to the widely-based (and incorrect) conceptualisation of learning mathematics at the origin of the 1950s and 1960s movements to improve learning of scientific subjects, whereby "knowledge" was measured by the selecting of correct responses to a relatively small collection of questions (Davis, 1983). Currently, the new wave of research in this area is emphasising what had been pointed out by pioneers such as Jean Piaget, namely that it is a mistake to focus only on "right" and "wrong" answers, and ignore the reasons why people select different answers. In other words, the new generation of research on numeracy, similarly to that in reading and writing, has shifted the emphasis from the products back to the process.

69. Another reason often advocated to explain the less-than-satisfactory results in mathematics learning is, even more basically, that the approaches used so far have not aimed at developing teaching/learning strategies specific to children. Speaking of modern mathematics, S. Papert says explicitly that "it did not come from a process of invention of children's mathematics but from a process of trivialization of mathematician's mathematics." (Papert, 1980).

70. The combination of the two trends of thought might find in the NIT a particularly useful tool to progress in understanding as well as in developing new approaches to the learning of mathematics. The computer has already been

given an important place in the learning of mathematics concepts, for instance by way of the LOGO system. For older children, pocket calculators are already performing a useful role in animating the debate, if not in providing answers to it. In the area of remedial education, computers have been used to analyse error generations. This has provided important information on thought processes which has led in turn to improved learning.

71. In this area, the field where most of the results have been gathered is also where there is less certainty as to the beneficial effects of the NIT on learning: the learning of mathematics by drill-and-practice. A typical result would indicate that drill-and-practice has a positive effect on computational mathematics, but that increases in conceptual understanding of mathematics are sometimes greater, sometimes less, than for control groups. (Ragosta et al., 1981)

72. In this area, as in others, the potential of the NIT is as great as the need to understand the variety of observed phenomena and the possible development of new approaches to learning. In particular it is important to analyse what works and what does not work, in which learning environments, with which learners and which technologies. In this context, in mathematics as well as in reading or writing, given the accumulation of uncertainty as to the processes underneath, generating the right questions is possibly more important than finding answers to meet what look like the most urgent needs.

The evolution of basic skills

73. A recent report says cogently: " A continuing dilemma for curriculum decision makers in all school systems is created by the concept of basic skills. There is adherence by many people to the idea that reading, writing and arithmetic are the "basics" of education. Conservative or traditionalist educators tend to combine this notion with an emphasis on drill and practice, and uniform standards. On the other hand, education should prepare students for contemporary society and/or the future, and should do so for as many of the students as possible. The question of what skills are to be offered by the school system and the best processes of teaching and learning to achieve not only skills but those higher order goals expected of education are issues that tax the judgment of educators and politicians." (Crossley, 1983)

74. Another author brings the issue of basic skills down to its own basic level, its link with literacy: "Literacy is not just a formal skill; it is also a political decision. The decision to want a literate society is a value-laden one that carries costs as well as advantages." (Hirsch, 1983)

75. The above quotations highlight some of the main issues in the debate on basic skills and on literacy. One is that the definition of basic skills is, to an extent, one of convenience, dictated more by what are supposed to be the needs of the time for integrated social life than by what are supposed to be the needs of single individual lives. The second is the translation of convenience into uniformity, one further step away from individual specificities, perhaps one towards social equity. The third is the notion that the promotion of literacy, whatever its definition, carries costs as well as advantages, for individuals as well as society.

76. The new information technologies and the knowledge and skills related

to them have come to occupy a place of prominence in the revived debate on basic skills and on literacy, where they are often seen as fullfilling a possible double role. They are counted upon to insure the acquisition of "established" basic skills and identified as indicators of new ones to include in the making of the new literacy. A first corollary concern in the debate relates to their possible role in making some basic skills obsolete. A second one bears on their possible impact on the gap between the satisfaction of societal needs and the respect of individual differences. A last one, implicit in many discussions, looks upon the NIT as the "miracle" remedy to make education succeed where old ways have failed.

77. The analysis developed before reveals that the NIT have the potential to play all the roles expected of them, within reasonable limits. The fact that not much is known as to their specific effects on learning is only a temporary drawback. Given enough investments in research and experimentation work, the understanding will be reached as to the details of their functions at all levels.

78. The evidence produced so far indicates that the NIT can be of assistance in the teaching/learning of the "old" basic skills. Reading, writing and numeracy can be facilitated by the use of the computers, although it is becoming clear that the observed benefits might come at a price. Speed of reading might be increased at the expense of text comprehension. Multiformity of reading materials can be achieved more easily, possibly at the expense of literacy levels. Literacy in the 3Rs could be acquired earlier in life at prices still unknown in terms of individual development. Writing can be facilitated at the expense of sub-skills such as grammatical or spelling literacy. It could even be made obsolete by the increased availability of visual (graphic) forms of communication. Numeracy can be achieved with less effort and in less time, but possibly at the expense of the specific thought processes developed from some number manipulations.

79. But the impact of the NIT goes well beyond their possible influence on basic skills. They can create the need to acquire new ones. Some likely candidates are emerging more forcefully than others. They are linked to the largest potential of the NIT, access to information. Put plainly, once information and data can be retrieved at will, memory and recall skills, central to established teaching/learning methodologies, will become peripheral to learning processes. Instead, other skills will acquire importance. The ability to deal effectively with novelty might become as important as the ability to deal effectively with repetition. Working with computers often develops a generalised attitude of enquiry, of "trying out", rather than relying unquestionably on the knowledge pre-packaged by the teacher. The need to develop personal learning strategies might become a must to orientate oneself amidst the options available. The list will only get longer in time.

80. As for "old" skills, the new ones will not necessarily come for free. The focus on individual learning might be detrimental to those who cope badly with learning without a human coach. The multiplication of options and possibilities might handicap further those who, in the absence of firm guidance, tend to "get lost" or to resort to earlier learning attitudes that are not necessarily beneficial. In short, the strong learner might grow stronger, the weak weaker. The consequences for uniformity, individual differences and, in the end, social equity might be substantial. Unless...

81. As in the best stories a new character could perhaps be brought on stage who, as the "deus ex machina" of Greek tragedies, will, by means of special powers, solve the problems possibly created by the NIT, or like the medieval philosophers' stone will turn the vile metal of basic skills into golden intelligence, thus providing all humans with power of their own to counter the possible harmful effects of the technologies. Learning to program a computer, most seem to believe, will do more for people than making them acquire a basic skill: it will expand their intelligence, it will develop their brain, it will give them a thorough, sharp mind. Humans will then grow all the wiser to avoid "technological" prejudices.

The "other virtues" of computer programming

82. Although caricatured, the issues raised in the previous paragraphs are very real in their substance. A number of policy decisions as to the introduction of the NIT in education rest on the assumption, at times more explicit than at others, of the "other virtues" of computer programming. Many heated debates on the curricular value of computer programming develop around the belief of some, and the disbelief of others, in the therapeutic value of this skill for the pupils and for the institution.

83. As a recent report puts it: "There was a time when it was generally believed that in learning how to do geometry, one learned the generally useful skill of thinking deductively and rigorously. Similarly it was believed that in learning Latin one disciplined one's mind and made it thereby more conducive to learning in general. More recently, it has been suggested that the teaching of computer programming might be an effective vehicle for the teaching of generally useful cognitive skills. There is very little evidence that the expectations for geometry and Latin were warranted. What reasons are there to expect that the learning of programming would produce more substantive results?" (Nickerson, 1982)

84. The debate around computer programming rests on a scant data basis indeed. Little is known as to the nature of the skill or its cognitive benefits and even less on the "transfer" value of whatever is specifically acquired. Without doubt this is an area where investigations, thus adequate investments, are needed especially urgently. Among the many aspects of the problem to analyse, important ones, with immediate relevance to education, would be:

-- The definition of the concept of computer programming;

-- The cognitive prerequisites to its learning;

-- Its cognitive consequences, including the issue of transfer.

85. As with many other skills when examined at close range, computer programming ceases to look like the convenient unitary label it is often taken to be and reveals its real nature, which is very complex. Defined as a body of knowledge or a skill to master, computer programming can entail different cognitive prerequisites and have different cognitive consequences depending on a number of factors. Among them, the programming language is as influencial on learning as is the specific kind of software it is meant to produce. The hardware configuration, the learning environment, are all additional, and

important, factors to consider when establishing learning approaches in this area, or when assessing the learning taking place.

86. One way to analyse the cognitive prerequisites of computer programming is to study possible correlations with other and better known cognitive abilities and factors. After having surveyed the scant literature in this area, a recent report draws a tentative diagnosis: a number of cognitive skills have been identified as possible correlates to programming skills but only very few have been the object of investigation so far (Pea and Kurland, 1984). The list includes items such as memory capacity, analogical reasoning (possibly a crucial skill for transfer), conditional reasoning, procedural thinking, temporal reasoning. Among the few investigated, mathematical abilities top the list, followed by IQ correlational studies. In both cases the typical correlation found is either modest or unclear. In the words of the reviewers, "to our knowledge there is no evidence that any relationship exists between general maths ability and computer programming skill once general ability [intelligence] has been factored out. Nonetheless, general maths ability per se cannot yet be ruled out as a possible prerequsite to the successful mastery of computer programming skills".

87. The correlation with IQ has been explored only indirectly, in relation to the ranking or scores in programming courses rather than with programming skills per se. In this context, adults' IQs have been observed to correlate, albeit modestly, with such indirect measurements. It is worth noting that no relationship has been established between the performance of adults on such scores and their subsequent performance in computer programming in the work place (Pea and Kurland, 1984).

88. Besides the difficulties inherent to the nature of the skills to analyse, still poorly understood, or the influence of outside factors, still largely uncharted, the study of the cognitive correlates of programming skills is beleagued by a number of other problems. Among the factors qualifying as major determinants of learning one could easily count the age of the learners and their degree of familiarity with the computers, prior to the tests.

89. Cognitive abilities by age are obviously a central issue in the debate on how and when programming should be taught in schools. A recent survey of U.S. evidence proposes broad tentative conclusions in this area (Becker, 1982). Children in grades K to 4, the report says, can learn rudimentary programming operations, particulary in special languages like LOGO, in which almost all operations are built from a few primitive operations. At about age 11 or 12, the report continues, a general improvement is observed in planning general structures and devising comprehensive computer tools, but only after a good deal of effort and guidance on the part of the instructors. Students in grades 6 to 8 seem, on average, sufficiently mature to understand the abstractions involved in programming. Older students, on the other hand, seem to separate into two groups: a small proportion who are personally interested in programming activities and a larger proportion who view the computer as just another subject in the curriculum.

90. Another report, surveying French computer-related experiments in schools, suggests that great caution should be used in generalising results by age, as the differences within same-age groups could be as large as the differences found between groups (Naymark, 1983). An in-depth analysis of a

LOGO experiment in primary education has revealed that only two thirds of the children have no difficulties in mastering the concepts and the relative programming activities. The remaining third experience difficulties in learning the same concepts and usually abandon programming above a given threshold of complexity. On the other hand spectacular results, well above their usual school performances, have been obtained with no more than 2 or 3 pupils per class, notoriously shy and withdrawn.

91. Within a school population of more modest social origin, an experiment of computer-based remedial education, has also led to differentiated results. The computer was found to be a formidable pedagogical tool to bring about improvements in the social and psychological make-up of the pupils. Its impact on their school performance was however uneven. Good, even spectacular results, have been obtained with no more than half of the pupils. With the others, improvements have been obtained only on some of their assessed deficiencies, such as in learning concepts of geometry, in overcoming problems of lateralisation, or in holding prolonged concentration on a task (Naymark, 1983).

92. In general the results reported in the literature on the learning of computer programming show a variety of outcomes ranging from enthusiastic, to cautious to negative ones. Some of the differences in the results have been claimed to derive from the different programming language used in the studies. With older learners, some say, the language chosen does not make a big difference in the observed outcomes. More important in these cases seem to be issues such as the resources available in the programming environment, how programming instruction occurs and the amount of program writing and debugging students engage in. (Pea and Kurland, 1983)

93. For children, on the other hand, the computer language could make the difference between learning and not learning. Not much disagreement exists on children being more successful at learning LOGO than BASIC, for instance. Yet the issue of language per se, if taken too exclusively, could prove to be misleading. Perhaps, some authors say, it is not the language that makes the difference but rather its "programming environment". In this context, many of the alleged advantages of LOGO over BASIC as a language for children could lie in the sophistication of LOGO's programming environment (Pea and Kurland, 1983). For example, LOGO has a much more sophisticated editor, more detailed error messages, better debugging procedures and greater finesse in creating and manipulating files.

94. Yet other studies identify a main factor in determining performances in computer programming in the prior familarity with computers. It would be a truism to say that differential access to home-based computers could explain some of the better performances observed in schools. In addition to such common-sense observations, harder data are being gathered which tend to confirm the above hypothesis.

95. Studies on adult learning have shown in Scandinavian countries how, when learners have used computers in their daily work for some time, the skill of programming them is acquired at a higher level and in a shorter time (Ruoppila, 1983). Surveying a body of research work on novices vs expert adult learners, a recent report confirms the existence of large differences between the performance of the two groups (Pea and Kurland, 1983). Among the most relevant results one could mention that the acquisition high-level

computer programming skills seems to be characterised by a giant assembly of highly specific, low-level knowledge fragments.

96. Additionally, large differences have been found in the way experts, intermediate and beginner programmers develop mnemonic strategies: for instance, experts cluster the keyword commands according to meaning whereas novices use a variety of surface ordinary language associations. Finally, a common result concerns debugging techniques: experts read programs for flow of control (execution), novices use line-by-line (as text) techniques. It is interesting to note that similar "strategic" differences phrased in terms of deep meaning or superficial connotations of concepts and processes are emerging from studies of novices and experts in the field of physics (Nickerson, 1982).

97. Although far from exhaustive, the data analysed in the previous paragraphs are convincing enough: the hopes on the cognitive benefits to be gained from computer programming skills might be, to an extent, unrealistic. Diversity seems to be the key word in this area. The skills rest on an aggregate of subskills, the study of which has only just started. The cognitive prerequisites for acquiring them vary accordingly. Not all learners have them. The cognitive consequences also vary, depending on a number of factors, suspected rather than charted. Yet, a number of people in various situations have been observed to perform surprisingly well on computer programming tasks, suggesting important gains at the cognitive level. Clearly, computer programming has a cognitive value. It remains to be seen in which conditions,with what people and to what extent the expectations could be satisfied.

98. Given enough investment, in terms of time and research, it might well appear that computer programming can facilitate, without being necessary nor sufficient, the development of particular cognitive abilities. Planning, precision, generation and testing of hypotheses, formulation of problem-solving approaches, are all cognitive abilities involved in computer programming, at different degrees. Probably the learning of computer programming will prove to be of benefit to these more general cognitive domains. In the affirmative, the debate on the desirability to teach computer programming to all pupils, and, consequently, on the curricular status it should be given, could well end by endorsing a weak rather than a strong hypothesis as to its cognitive power. But even then the question will remain of whether the same cognitive effects could not be achieved without the computers and with other teaching/learning methodologies.

99. The question of the hidden costs and cost-effectiveness of the NIT in learning is part and parcel of the debate on the cognitive aspects of learning basic skills, the old as well as the possible new ones. The question is also central to the general debate on the role and impact of the NIT on learning. This section has highlighted what that can possibly be, through a series of arguments worth bringing to light in these conclusive paragraphs.

100. The evidence available tends to support the general contention that the NIT have an impact on learning processes. The same evidence, however, does not provide clear grounds as to what processes are affected most, in which learning situations, with what people. Such a situation of uncertainty as to the specific impact of the NIT seems to be determined more by the current

understanding on learning (which is inadequate) than by an insufficient understanding of the technologies.

101. Trends are emerging, however, which indicate how the situation might evolve in not too distant a future, under the combined effect of progress in the cognitive sciences, where research investments are growing, and enlarged introduction of the NIT as support tools of experimental paradigms. The foreseeable picture of the learning sciences is therefore one where the NIT can very well play a central role in fostering understanding, although, most probably, at a price.

102. The evidence discussed before shows the manifest value of the NIT as a working partner for the researcher. The same evidence, however, warns that the partner can grow rather demanding. Its hidden power rests on the ability, unique to the NIT, to perform simultaneously the double role of "revealers" and "analysers" of learning processes. The NIT will help unveiling the underlying dynamics of cognitive factors. They have also the power to analyse the processes quickly, effectively and at reduced costs. This double ability makes the NIT extremely acctractive for research on a cost/effectivness basis. Their appeal might however conceal their power to introduce important biases in the understanding gained through them on learning.

103. When using the NIT as "revealers" of learning processes, it will be inevitable to introduce a selection on the research targets. The processes most often observed will be those which are observable via the new information technologies. Quickly, these will also become better understood among the possible array of processes on the research agendas. The risk of losing the others through the familiar chain of neglect, oblivion and, finally, denial is not unsubstantial. The next section, on pedagogy and education, shows how the NIT can be equally powerful in teaching/learning situations by transfering to these other levels their unique ability to perform the double role of support for the processes and means for their analysis as well as the risks this ability entails.

Section II

EDUCATIONAL STRATEGIES

> "The view that students learn what they are taught is definitely too simple to be a useful guide for design of instructional material and teaching." (FBPCS, 1983)
>
> "Heresies perform an essential function -- they keep people's minds on the alert." (Reeves, 1981)

104. The strength of any chain cannnot exceed the strength of its weakest link. At its outset, this section's contribution to the understanding of the possible relationship between NIT-based and school-based learning identifies itself as one of many possibilities and few certainties. In that respect, this section reflects the status of the current understanding on the impact of the NIT on learning processes, which, as analysed previously, is itself one of exploration and enquiry more than one of certitudes and confirmations.

105. Within such a framework of caution, this section develops further the analysis, in subsequent steps. It starts with the main conclusions from the previous section on the impact of the NIT on learning processes and discusses the implications for pedagogical approaches. Next, it attempts to apply pedagogical methodologies to educational practices, by considering the ways in which the institutional system could or would accommodate the resulting changes. In particular, this section highlights the implications of possible changes in formal education with respect to specific concerns such as on equality.

PEDAGOGICAL APPROACHES

106. The current link between pedagogy and the psychology of learning is no stronger than usual. Progress in the latter is having only a partial effect on the development of the former, and this with considerable delays. In that much, the tradition is being respected. Pedagogy and the cognitive sciences have followed rather separate paths in the past, with occasional bridges arising between them, when some major theoretical understanding in the latter has been transferred and adapted to the former.

107. The model of intelligence as being made up of a general factor

accompanied by a host of specific ones has been instrumental in the development of quantitative approaches to cognition as well as to pedagogy. The widespread introduction of tests to assess educational performances has been one of the most visible forms whereby such theoretical models of cognition have been used in institutional practices. Understanding of the strong influence of the environment on learning, together with the findings on the importance of early learning have accompanied the development of "active" and "participatory" pedagogical models targetted at the younger children. Models of the development of cognitive abilities as a mechanical response to stimuli (behaviourism) have found widespread applications, at least in some countries, as drill-and-practice approaches to learning. More wholistic models of cognitive development such as that developed by Jean Piaget have had a much harder time to penetrate, either pedagogy or education.

108. The more recent generation of research on learning processes has introduced some changes in the picture of what is important in learning and how it could be supported. A main change discussed in the previous section is the shift of the research target away from the learning products and back to the processes underneath. The current emphasis of research on cognition is on the concept of learning as personal discovery, problem solving and information processing activities, rather than acquistion of specific skills or "chunks" of knowledge. Within this context, another important series of results has reinforced the assumption on the importance of early learning habits for later performance.

109. But perhaps the most important common implication of the most recent findings is the hypothesis that learning could be a much more complex process than previously thought. More than the result of cumulative growth, learning abilities seem to be a question of modification, diversification and differentiation. The most recent evidence seems to indicate that, far from developing along some kind of linear algorithm, learning develops rather like a branching tree of increased complexity, with each part retaining a useful function for specific tasks.

110. The most immediate translation of these research trends into pedagogical approaches is in terms of a pedagogy centred on the learner (individualised or autonomous learning) constructed on a diagnosis of his/her previous learning habits and adapted to the ongoing learning processes via a continuous diagnosis of the learning performances. In particular, and in line with the cognitive science, the new generation of pedagogical approaches would reflect the move away from broad general theories, thus from unitarian models of learning, and the development of a variety of specific approaches, adapted to specific learning and specific learners. A first observation on these objectives is that they are certainly ambitious for pedagogy. A second is that they have always been.

111. For a long time, pedagogues around the world have been developing approaches to education aiming at rather similar objectives. Their recommendations did not rest on the understanding of learning processes, then unavailable, but they were firm about the pedagogical merit of individual attention, interactivity, interest and motivation, flexibility, personal exploration and discovery. The so-called "Socratic approach", currently adopted in computerised lessonware, is at least as ancient as Socrates' maieutics. Similar approaches have been at the basis of all the major pedagogical developments of this century. Much the same principles guided the

Italian M. Montessori at the turn of the century, the Swiss E. Claperède in the 20s, the Frenchman C. Freinet between the two World Wars and the Americans J. Dewey and B. Bloom in the 30s and 50s. In general, it would be hard to find in the last few decades, an example of educational innovation which would not be inspired by one or the other of these historical founders of modern pedagogy.

112. Why, then, this revived interest in methods that have been tried successfully for a long time already? Why this tone of "newness" on pedagogical approaches which are in fact, rather old? The answer is because of the progress in cognitive sciences and because of the power of the new information technologies. The research findings from the cognitive sciences give "hard", "scientific" grounds on "soft", although highly respected, pedagogical principles. The technologies offer the instrumental opportunity to translate the specifics of the learning processes into pedagogical practices in line with established pedagogical principles. More than that -- and this is what again is unique to the NIT -- they assure at virtually no extra cost the possibility of performing the kind of continuous evaluation which is central to known pedagogical models and confirmed by research results. It is the double role of "revealers" and "analysers" that makes the NIT potentially powerful in the area of the learning sciences. It is their double role of "translators" and "evaluators" that makes them equally powerful in pedagogy.

The NIT as "translators"

113. A number of taxonomies of computer software and courseware are based on the pedagogical approaches implicitly or explicitly built-in. Although varying in their categorial definitions, the proposed classifications are developed around the same indicator: the amount of control and independence of the learner vis-a-vis the computer. The categories usually range from the best known examples of Computer Assisted Instruction (CAI), essentialy drill-and-practice programmes, to the most recent and sophisticated programmes, where both the learner and the computer can play an active role. It has to be stressed at the outset, that the distribution of the programmes produced so far across the various categories is highly uneven. The more sophisticated the pedagogical approach taken, the smaller is the number of programmes available on the market. In that, the understanding gained in cognitive science is showing itself only slowly in computer-based pedagogy.

114. The best known examples of CAI, the computer-controlled CAI, is based on a behaviouristic approach to learning. Typically, the programme presents a frame containing a portion of the lesson material to be learned, asks a question and evaluates the student responses. Selects the next lesson frame based on that response and, optionally, keeps a running cumulative score. In the words of one author, "this is the 'hospital' model of education, in which the student is regarded as a patient to be treated, or 'programmed', by the computer. 'Individualisation' in this case means only that one student may receive a different sequence of prestored frames than another. The programme does not build a model of the student's knowledge and conceptual gaps and/or does not diagnoses his/her difficulties along the way. Computer-controlled CAI applications are useful for teaching the acquisition of facts and for helping students memorise and consolidate factual knowledge. The two major varieties of such pedagogical uses of computers are drill-and-practice and

tutorial programs. Most of the software and lessonware produced so far belongs to this category" (Feuerzeig, 1981). Another example of computer-controlled approaches to learning are some pedagogical games such as word games aiming at developing language skills.

115. At the other end of the spectrum one finds what can be called the student-controlled CAI. Here learning is viewed as an active process of investigation. The program exercises no control over the learning situation. The computer simply responds within the limitations of the program's repertoire to the student's commands. There is no prescription of what experiments the students should perform nor do the programs coach the student in any way. Software of this kind are rarer. Examples exist in topical learning areas such as mathematics, physics or statistics (Feuerzeig, 1981).

116. The so-called "expert programs", created in topical areas can belong to either one of the above categories. They have been mostly developed in medicine and applied sciences. A similar classification is that of "simulation programs", developed mostly for teaching physics, chemistry and biology. They use graphics to simulate experimental conditions. Another topical kind of program is that developed to teach foreign languages (Crossley, 1983), using computer operated slide projectors and tape recorders, where graphics can be associated with sound patterns.

117. In between the above categories, there are the so called mixed-initiatives systems, the closest to a Socratic approach to learning. Student and computer engage in a dialogue. The student can ask questions to the computer and the computer can respond as well as ask its own questions in turn. Usually the student works on a complex problem-solving task. The problem can have multiple solutions or no solution. The emphasis is on learning problem-solving procedures and strategies rather than on finding "the answer". Examples are developing proofs in logic or geometry, analysing unknown chemical substances, or finding faults in electronic circuits. (Feuerzeig, 1981). Other programmes that could be classified as mixed-initiative ones are those developed for computerized homework, where in association with classroom activities, the computer can provide clues to overcome difficulties or revert to easier problems. Candidates for this category are also the programmes that allow students to create their own computerised lessons. This, an author informs us, seems to be one type of programme most enjoyed by the students (Crossley, 1983).

118. The systems developed towards specific developmental objectives form a category of their own in the field, even though, strictly speaking, they could be classified as student-controlled ones. Systems such as LOGO are based on a genetic approach to pedagogy, stemming from the recognition of the role played by spontaneous learning (learning without teaching) in the cognitive development of the child.

The NIT as "evaluators"

119. The information discussed in the previous paragraphs indicates the extent to which cognitive models of learning are being translated in computer-based pedagogical approaches. Some additional information exists on the ways in which the NIT have been put to use to evaluate the pedagogical process. Programs have been developed to analyse specifically the error

patterns of the learners (e.g. BUGGY). Others monitor the response pattern by the students and provide feedback on acceptable alternative solutions to techers who can then modify the classwork accordingly (e.g. ESOPE). Yet others compare students' performances with models of experts' performances and establish a diagnosis of the "missing skills" (e.g. WEST). The list of strategies for dynamic evaluation can only grow longer in time.

120. Few would dispute the potential of the NIT to establish diagnosis on learning, to evaluate performance and keep track of students' progress on an ongoing basis, over a period of time, without disrupting the learning itself, as tests, or teachers, usually do. At least for the most sophisticated types of programmes, pedagogical quality is insured by respecting a number of criteria including interactivity, recognition of errors and diagnosis of conceptual difficulties in the student, modulation of the learning session according to the competence and motivation of the learner, generation of dynamic feed-back, flexibility of pathways towards solutions.

121. Much the same virtues are advocated for computer-based learning by those who have used it. One of the most comprehensive sources of information on the views of the clients is a recent report by the French "Institut National de Recherche Pedagogique" reviewing a ten-year experiment on computer-based classroom learning (INRP,1981). Asked to indicate the most innportant characteristics of computer-based learning, the students agreed on a number of issues. The computer computes fast, they said. It gives immediate feed-back (used by most students for immediate self-correction, a type of self imposed drill-and-practice). The computer forces the learner to think and clarify the approach to subject matters. "With the computer, it is the pupil who works, whereas in the classroom it is often the teacher". The possibility of individual tutoring is particularly appreciated: "There are 35 of us in the class, so the teacher can't tell each of us individually what to do. With the computer, it's as though there were one teacher for two pupils". Personal autonomy with respect to the teacher is also appreciated: "We don't feel we have the teacher on our backs. The teacher is more in the background...", "the teacher isn't always on top of us correcting our mistakes". "We can give a wrong answer without looking stupid, which we can't in an ordinary lesson". "We're allowed to make a mistake". "The computer asks us a question and we answer, and if we get it wrong we can try something else". "The teacher is only there in case he's needed". Personal autonomy with respect to time is another point mentioned: "we have more time to think and we can slow down or go faster depending on what we can manage".

122. So far the analysis is promising: the NIT can play a role in fostering understanding of the learning processes and in applying it in practices of pedagogical quality. The analysis is equally clear on the risks involved, on the "perverse" or just the "unexpected" effects possible on the way. Cognitive scientists and pedagogues are faced with a highly appealing and difficult task: how to bend the NIT to support their work, how to maximise the advantages while keeping the disadvantages under control. The balance is difficult to strike, the challenge worth considering.

123. At this point in the report, the ground is ready to ask the next set of questions: what impact could the NIT have on learning as it unfolds in the institution of education? How to transfer the cautiously optimistic expectations from the experimental conditions to which they apply, to the much broader area of ordinary schools, without weakening the partition between the

useful and the useless, the promising and the damaging, the possible and the unrealistic? If their promises are so enticing to the pedagogue, if their use seems to be so appealing to their (so far sparse) young clients, how can the educator and the whole school population also be made to benefit? How can the pedagogical objectives of the educational system be attuned to the NIT? And finally, what would be the impact of the large-scale introduction of the NIT in education on the other objectives and functions of the system?

FROM EXPERIMENTAL TO MASS EDUCATION

124. The stakes are clear. The NIT qualify as a vehicle to integrate in mass education some of the pedagogical principles familiar to innovators, reinforced by the "hard" cognitive foundation currently being built. The resulting pedagogical methodology -- it has to be stressed once again -- is not exclusive to the technologies. Given time, resources and specialised manpower some, if not most, of what is currently developed could be carried out without the new technologies, by people working with ordinary educational tools. This has happened in the past and could happen again, but -- and this is the crucial point -- not everywhere in education. Modern pedagogy has entered the classroom mostly in isolated innovative schools, where there is a long-standing tradition of children learning at their own pace, according to their own abilities and interests, within a flexible curriculum, under the guidance of personal tutors.

125. Usually, the circumstances of such innovative education have been quite exceptional: outstanding teachers, adequate resources, a supportive community. These conditions are not easily reunited in the educational system, where the absence of them is more the rule -- a formidable barrier to any large-scale introduction of the pedagogy underneath. This is the point in the relationship between pedagogy and mass education where the NIT have the largest impact to make. Their role is not so much to make a new pedagogy available to all pupils -- the pedagogy proposed is not entirely new. Their potential is to offer a service of quality, based on sound pedagogical principles, in situations that are not exceptional to the system, at a cost which could be afforded by all.

126. The important question now is to ascertain whether the historical obstacles preventing the large-scale introduction of modern pedagogy could be removed to make room for the new technologies, whether the educational system can operate the shift from a pedagogy of convenience to a pedagogy of efficiency.

127. When considering the ways in which learning is organised in the typical classroom of OECD Member countries, not much is found suggesting that it will be easy, or painless, to make room for the pedagogy carried by the NIT. Current practices do not allow much autonomy to the learner, nor much interactivity or personal exploration and discovery. A large-scale survey of US schools has revealed classroom situations that are common to other countries (Goodlad, 1983). "Teachers varied in the quality of their lecturing, for example, but 'teacher talk' was by far the dominant classroom activity. Teachers rarely encouraged student-to-student dialogue or provided opportunities for students to work collaboratively in small groups or to plan,

set goals, determine alternative ways of achieving these goals" "the emphasis was on recall, not on problem solving or enquiry". "We received an overwhelming impression of students' passivity. Furthermore they apparently rather enjoyed the dominant activity of listening, which demands so little of them".

128. Besides the teacher-dominated instruction, very little time if left to the class to engage in other activities, either individually or in small groups. "At both elementary and secondary levels, approximately 75 per cent of class time is instructional, while most of the remaning time is spent on routine work such as preparation for instruction, role-taking and cleanup". "Nearly 70 per cent of total class time involves verbal interaction or 'talk'". "Approximately half of the verbal interaction time is devoted to teacher talk" "Less than a fifth of the time involves student talk" "Teachers, therefore 'out-talk' students by a ratio of nearly three to one". "Barely 5 per cent of instructional time is spent on direct questioning (of a student by a teacher)". "Less than 1 per cent of that time is devoted to open questions which call for more complex cognitive or affective responses". "Nearly 67 per cent of the elementary students and 75 per cent of the secondary students work as a total class. Less than 5 per cent are found working individually and less than 10 per cent are found working in small configurations".

129. The conclusions of the authors are paradoxical: "To the extent that talking requires the organisation of thought and can be an important avenue to learning, teachers were doing most of the learning".

130. When considering the ways in which the NIT are penetrating the schools, the evidence mounts on the pessimistic forecast being essentially correct, at least for the time being. A number of obstacles appear more clearly than others. The teachers' "territorial imperatives" set powerful boundaries to the realisation of the potential of the NIT as do their own level of competences. Usually, teachers are careful to teach only their grade level and not to transgress on the next grade level (Burnett et al., 1983). They have also been observed to restrict students' learning to their own level of familiarity with the new technology-based learning systems (Crossely, 1983, Naymark, 1983).

131. Variables such as the organisation of the classroom have also been found to be crucial to success. The software available does not usually fit in with classroom work. Most products developed for classroom uses of micros allow profitable use by only one child at a time. For teachers to use effectively a device which is primarily geared for a single user when they have one machine per 30 children demands, at the minimum, a major planning effort (Becker, 1982). In the end, the technologies are forced to fit in with classroom practice rather than the reverse. Most of the software available is neither individualised nor adaptive. An entire class works on the same material at any given time and is expected to proceed through the course at the same rate (Feurzeig, 1981).

132. Should the situation evolve without major qualitative changes, the schools of the future would resemble those pictured paradoxically by S. Papert, who feared that the system would just absorb the change, by using "new technologies to reinforce educational methods whose very existence is a reflection of the limitations of the precomputer period" (Papert, 1980). A

French author echoes similar concerns, and emphasizes the conceptual and organisational difficulties inherent in the "quantum leap" forced on schools by the new information technologies "The main obstacle... is institutional resistance on the part of the school to any organisational change tending to displace the teacher's lecturing as the source of knowledge in favour of learning based on manipulating and experimenting. This is not just an ideological barrier, as all too often stated, because that fortress has already been well and truly breached. The difficulty is that no-one is quite sure how to approach it, and there are very few people one can turn to for guidance. It is not just habits that have to be changed, but the whole organisation of work, time and premises that has to be rethought." (F. Robert, 1983)

133. On a longer-term perspective, the forecast could however be less pessimistic. In countries where the NIT have entered ordinary classrooms more extensively than elsewhere, where teachers and pupils have had more time and opportunities to use, essentially, the microcomputer, trends are emerging indicating that, in the long run, desirable qualitative changes could, perhaps, take place.

134. The Centre for Social Organisation of Schools of the John Hopkins University, is analysing the use of microcomputers in ordinary United States schools, at the primary and secondary level (CSOS, 1983 and 1984). A first important result of the analysis is that the introduction of the microcomputers in schools generates a dynamic, rather than a static, configuration. As time goes on and as more equipment is available and more teachers are involved, the use of the microcomputer evolves. Such evolution -- and this is the second most important result -- follows a pattern which remains specific to the level of the school (primary as opposed to secondary), the number of teachers involved (one as opposed to several) and the involvement of school administrators. The typical primary school uses the microcomputer mostly for drill-and-practice and remedial work, with a shift towards computer programming and computer literacy as more equipment becomes available. The typical secondary school uses microcomputers mostly for computer programming.

135. Resource constraints seem to have a different impact on primary and secondary schools. In the former, usually underequipped as compared to the latter, the equipment available is more evenly distributed across the school population. More microcomputers means here more children with access to them. In secondary schools, access is strongly skewed in favour of "programmers" as opposed to "drillers". Furthermore, an increase in computers results in increased time per student, rather than increased students per machine. In both elementary and secondary schools, the shift of initiative and control from the single enthusiastic teacher to a group of teachers and to school administrators correlates with a more even distribution of user time and type of use of the microcomputers.

136. Basically, similar evidence emerges from other smaller-scale observations of Canadian (Logan, 1983) and French schools (Naymark, 1983), with the conclusion that "in general, the picture that emerges is one with a strong flavour of trial-and-error, with teacher practices changing as their experience with computers grows, as their students' experience grows, and as the teachers themselves grow older" (Logan, 1983).

137. In terms of learning processes, the observed dynamics seem to produce, in the opinion of teachers, an impact which is essentially social and motivational rather than cognitive. Teachers in the large-scale US survey confirm some of the anecdotal evidence reported before in this report, namely that micros have led to increased student enthusiasm for schooling; to students working more independently, without assistance from the teachers; to students helping one another and answering each other questions; and to students being assigned to do work more appropriate to their achievement level. Other smaller-scale studies tend to confirm the teachers' perception of classroom changes. Regular use of computers in their classroom -- they say -- has caused their style of teaching to change from teacher-centred to student-centred. The presence of the "computer-expert" students in the classroom has had the effect on the teacher's perception of students in general, to a more positive view of their capabilities (Miller et al., 1982).

138. The pedagogical approaches implicit in some of the classroom uses of microcomputers seem therefore to bear their fruits, at least at the social and emotional level. As more sophisticated evaluation methods become available, as understanding on learning processes increases and more elaborate software is produced it will be possible to ascertain the merits of the approaches on more cognitive grounds.

139. These results are encouraging. The trends, however, remain fragile. There are still too few computers per school, too few teachers trained to use them, too little time for students to spend with them. By January 1983, in all categories of US secondary schools, a majority had at least one microcomputer, about 60 per cent had two or more, only 40 per cent had five or more. At the same epoch, the majority of primary schools did not have any microcomputer, only 46 per cent of them had one or more. Elementary schools then had a ratio of 100-200 pupils per computer, with an average access time per pupil of about 15 minutes per week. The median student/computer ratio in junior high schools was 181 : 1, the ratio went down to 88 : 1 for the best equipped secondary levels and the combination junior/senior highs. This means that the median of secondary school students using micros in a week ranged from 10 to 20 per cent, with a median of about 12 hours of use per week per student user. As for the teachers in about half of the schools with micros, only one or two teachers at most were found to be regular users (CSOS, 1983 and 1984). In Canada by the end of 1983, there was approximately 1 micro-computer for each 250 pupils (Crossley, 1983). The situation in other countries is no better, and often far worse.

140. The above figures indicate clearly that the introduction of the NIT in ordinary schools is only starting. By that, these figures suggest caution against too hasty a generalisation of the preliminary results available. But the trends observed suggest also encouragement to continue. The NIT do hold a potential for education worth exploring, worth investigating via research, experimentation and plain practice in the classrooms. The fact that they might be beneficial to learning makes it all the more important that the clientele should be large and include all levels of schooling, all types of schools and all pupils, without distinction of social class, origin or sex.

EQUALITY ISSUES

141. Twenty odd years of studies on "equality and inequality" have established a fine mapping of the processes involved, have thrown light on what rules govern the game. In all Member countries educational expenditure per capita increases with the level of schooling. The resources available for education resemble very closely the socio-economic mapping of the areas served by the schools. The socio-economic profile of students' prospects at the outset of their educational careers resembles closely that of their family of origin, the generational matching reproducing both the class and the sex affiliation.

142. It would be naive to expect that a single innovation, such as the introduction of the new information technologies in the school, could alone dismantle what a century of educational policies and practices have been unable to make a dent in. Yet the awareness of the limitations of the cure should not make us reject its possible merit. Otherwise, left to its own dynamics, the introduction of the NIT in education could very well increase the differences, as some of the evidence shows already.

143. A discrimination by level of schooling is at work in almost every Member country. Secondary and vocational education receives better equipment, is equipped faster and with a larger variety of courseware. Primary education, which the learning sciences indicate unmistakably as the priority educational target in terms of cognitive development, are left systematically behind. Furthermore, most of the investment in basic education is going to remedial education in its latest years. One wonders at the possible savings in material and human resources if only the educational interventions were better targetted at the very beginning of the cycle...

144. The schools that could be defined as poor on former grounds tend to remain poor in technological terms. Unless specific public interventions are planned, as in some Member countries, the gap between rich and poor will grow only wider. The quality of the learning provided by the educational establishments will continue to reflect their status on the scale of privileges.

145. When the computers were introduced in the French upper secondary institutions on experimental bases, the evaluation of the outcomes included positive elements as well as less positive ones, including the real danger that the technologies create within the courses of study a new "royal line" for a new elite in the school population. Here the stakes at the basis of the familiar debate on the curricular status of "informatics" showed a different colour: in terms of equality, what matters is less its introduction as a separate discipline or as a subject integrated in other disciplines, but whether or not the new curriculum has a place on the agenda of the final examination. Here, almost inevitably, certification creates elitism (Naymark, 1983).

146. When the computers were introduced into US schools, patterns of inequality also emerged. Here, left to the initiative of single teachers, the NIT are often used to the benefit of the above average school achievers (CSOS, 1983 and 1984), when specific experiments have proven that most of the others can also benefit. Given the class bias in the two groups, one can only

fear that the saying might come true of "the middle classes learning to use a computer while the working classes learn to play video games". Without specific intervention to the contrary, patterns of inequality are only strengthened.

147. Although not many specific studies are available on the subject, evidence is also growing on sex biased inequality in the access and use of the new information technologies in schools. They amplify the existing segregation of lines by sex, when the NIT are introduced in the science rather than humanities lines. Given the uncertain (at best) correlation found between proficiency in computing and "maths" abilities, one wonders as to the pedagogical justificaton of the educational decision. A number of studies in the United States show how the perceived association with maths and sciences, together with the content of most software available, appealing to boys rather than to girls, are "scaring away" girls in much larger numbers than boys (Beyers, 1983). The fact that the levels of schooling where the technologies are introduced most are those where the sex biases are already deeply entrenched, namely the secondary schools, makes the forecast for technological sex biases in the population only more gloomy.

148. At the end of a section on "educational strategies" in relation to learning processes and the new information technologies, a number of considerations could be made, serving at the same time as a summary and as a reminder of the major issues at stake. Perhaps the most important one is on the very close link observed between the institutional management of learning and the management of the institution itself. It would be difficult indeed, in the analysis developed in the previous paragraphs, to separate the problems pertaining more specifically to the learning processes from those with a stricter institutional and corporate bearing. Learning processes do not take place in an institutional vacuum, nor do institutional changes.

149. Financial resources translate reasonably easily in equipment, teacher training programmes, computerised lessonware or research programmes on cognitive processes. The influence of financial factors on motivation, attitudes and readiness to change in the gatekeepers of the educational system is much less direct. Yet without such changes the other will not take place easily. The average school principal, the average teacher, the system as a whole have more than one legal way to oppose, transpose, filter and absorb pedagogical innovations. The history of education is not short of examples. The NIT can easily become an additional chapter in an already fat book.

150. The consequence on the learning processes, the modalities of the emerging pedagogical approaches need to be made clear and appealing to educators. Their educational advantages need to be spelled out in detail. The curricular implications need to be worked out, the boundaries between disciplines discussed, the organisation of the school and the school personnel redefined to everybody's satisfaction. The working agendas are not short of items. Carried out to its fullest implications the introduction of the NIT in education is nothing less than a revolution, as large scale implementation of modern pedagogy would have been if only it had been adopted.

151. Yet everything cannot be done at the same time. Reaction times of policy-making bodies or funding agencies are different from those of institutions, of researchers or teachers, organisers or curriculum developers. Priorities have to be established for the working agendas of the

partners concerned. Issues and problems have to be identified for immediate action; other reserved for further investments. In short, priorities for the future have to be established in terms of substantive work, of chronological perspectives. Before that, and perhaps more importantly in the uncertain area of the NIT, the criteria need to be established to select issues and to allocate them to the priority lists where they belong.

Section III

AGENDAS FOR THE FUTURE

> "The NIT can be regarded as a pair of spectacles through which the problems are defined, as well as what factors or dimensions are important in the problems, and eventually what the feasible solutions are. Learning and working with these glasses can radically alter the students' and the teachers' perceptions." (I. Ruoppila, 1983).

> "She stretched herself up on tiptoe, and peeped over the edge of the mushroom, and her eyes immediately met those of a large blue caterpillar, that was sitting on the top with its arms folded, quietly smoking a long hookah, and taking not the smallest notice of her or of anything else." (L. Carrol, 1869).

152. This chapter is on the working agendas to draw in order to answer the many questions raised in this report as to the impact of the NIT on learning processes in formal education. Its based assumptions, as discussed before, concern the nature of learning -- a multifacetted process depending on the learner's abilities and motivation, on the specific technological supports in the learning environment, and on the influence of a network of active agents external to either of them, the power relationship among these influencing factors -- shifting according to learning situations; the specific role of the educational institution in transmitting knowledge and skills to the learners while safeguarding its own institutional interests, and finally the nature of the new information technologies, which keep diversifying and changing.

153. This multitude of factors and actors determine to varying degrees, what is learned, how and to what purpose. It means also that, depending on the "determining agent" considered, not one but several working agendas can be drawn to answer the same questions on learning each responding to specific and, to an extent, independent, interests and concerns. The remainder of this section will discuss some of the ways whereby the issue of learning and the NIT can be approached in view of establishing working agendas for the future. It will show some likely alternatives, the work priorities which could emerge, and the ways in which these could be met. More specifically, this section argues that separate approaches could be developed on similar "learning" issues reflecting the interests of cognitive sciences, or of pedagogy, of the institution of education, of social and economic concerns. It then suggests

what the criteria could be to select within approaches and discuss some of the likely consequences for the overall integration of the NIT in education.

AGENDAS

The "cognition" agenda

154. As it emerges from the previous sections, the impact of the NIT on learning processes can be analysed in a number of ways. One of them is to say that the NIT can facilitate the acquisition of knowledge and skills, have unforeseen effects on what is still unknown on learning and, finally, be used to understand the processes themselves. The dual potential role of the NIT as "revealers" and "analysers" of learning processes has emerged forcefully from the analysis developed in this report.

155. Within this broad context, specific issues have emerged for research on cognition. They could be classified in their turn under three main headings concerning the impact on familiar learning processes, the identification of the cognitive processes most especially sollicited by the NIT, and the consequences for learning of having the NIT as its main support.

156. Under the first heading one would list issues related to the time organisation of learning, such as its acceleration, or its sequential organisation, as well as issues more directly relevant to developmental models of cognition. Possible lists under the second heading would comprise research on specific learning processes such as on strategies of thinking, learning problem solving and concept formation as well as topics on information processing such as orientation, anticipation, cue selection, perception, recognition, short- and long-term memory processes. An important place in this list would be devoted to the study of the cognitive benefits of learning computer programming and especially of its transfer value.

157. The third heading would cover more specifically concerns that could be called "existential". On this list one would include research on the effects on learning of looking at "reality" through the technological glasses, on the consequences for learning of the specific motivational and attitudinal factors triggered by the presence of the NIT in the learning environment, on their impact on interpersonal behaviour as well as on personality development. An important place in this list could be devoted to the impact of the NIT on the balance between "algorithmical" thinking as opposed to creative or lateral thinking.

The "pedagogy" agenda

158. A pedagogue concerned with the impact of the NIT on learning could draw a list from a different perspective. Its general guideline would be the assumption, developed in the previous sections, that the most promising role of the NIT in pedagogy is as "translators" of established cognitive and pedagogical thinking in models to be used currently in pedagogical practice at

affordable cost, and as "evaluators" of the effects on learning.

159. At the core of possible lists under this heading one would find the development of "real time" monitoring and evaluation techniques, of models of independent learning, of automatic assessment of errors, of rapid diagnosis of the profile of learning aptitudes. In other words, in this list the pedagogue's list would include the development of NIT-based applications of innovative pedagogical methods. Given its cost-efficiency, additional connotation of this list would also include specific considerations of the hardware requirements for desirable pedagogical objectives and their cost implications.

The "education" agenda

160. The inclusion of economic concerns on the working agendas is a clear indicator of a main pre-occupation of this report, namely that the impact of the NIT on learning be considered as something more than as an object of academic enquiry, or pedagogical modelling: that the possible benefits or shortcomings of the technologies for learning be considered not only in their own right but also, and foremost, in view of their possible applications to large-scale education.

161. This means that the working agenda drawn for education would include specific items related to the large-scale introduction of NIT-based learning methodologies in the familiar school settings. An important item on this list would concern the effect on learning of transferring experimental learning methodologies to ordinary school situations. The list would also include items concerning the impact on NIT-based learning of organisational variables such as the organisation of the learning environment in schools in terms of time, space and human interaction with other learners as well as with the teacher. An additional item would concern the analysis of the impact on learning of teaching practices that use the computer as a support alongside other supports without giving it the most prominent position.

162. This list is concerned with the reality of schools would involve the inclusion of other items concerning the ordinary school population as well as the established school curricula. On the former front, the list would include items on the personal profiles of the learners, in view of identifying the traits of those who learn best with the NIT and the reasons why. On the latter front, the items would include the development of curriculum prototypes, whereby the benefits of learning with the NIT could be insured and/or safeguarded in new curricular organisations of known or new disciplines. In particular, this list would give much space to the applications of the NIT to the acquisition of basic skills, such as reading, writing and numeracy as well as the development of new curricula centred on NIT-related knowledge and skills, aimed at achieving specific cognitive gains.

The "special population" agenda

163. The teaching-learning methodologies at work in formal education do not produce the same learning benefits across its population. Similarly, the NIT do not seem to have the same impact on all learners, with the patterns of differences in the two cases being not necessarily similar. A working agenda

built on the learning needs and possibilities of special education groups would respond to social and political concerns that are central to education.

164. Items in this list would include the study of the impact of the NIT on learning disaggregated by types of school learners. It would tackle the equality issue by studying the impact on boys and girls, the assessment of possible differences therein and of their personal and environmental determinants. Another section of ths list would concern the group of the low achievers and the impact of the NIT on their learning. Another set of items could address the learning needs of the handicapped. Yet another could consider the educational problems in sparsely populated areas and the ways in which learning by the NIT and especially distance learning could be of benefit.

The "manpower" agenda

165. Among the objectives of education, an important one is to educate the future manpower. A working agenda in this area would cover older learners, young people and adults and would be concerned with the specific learning processes of this older population.

166. A number of candidates for further investigation have emerged from the analysis developed in this report. No doubt many others could be also identified. Possible items in this list could include the impact of the NIT on the acquisition of knowledge and skills by novices or experts, the impact of established learning habits on the speed of acquisition of new ones, the specific role of the NIT on learning specific skills in training or retraining of manpower. In other words, the central theme of this list would be on the ways whereby the NIT could be used to make the acquisition of specific knowledge and skills by older learners more efficient on a cost/benefit basis.

SELECTION CRITERIA

167. Together with the development of working agendas, the future of learning and the NIT will be determined by assessing the wisdom of choosing one agenda instead of another. Besides the differences in their constituent items, thus in the specific publics addressed, the agendas developed before differ in other important respects, which are worth defining.

168. As discussed at the beginning of this report, the issue of learning and the NIT cannot be considered in abstract, as if learning occurred in a social vacuum. The active agents influencing what is learned, how and to what purpose are several. Their impact is of a different nature, follows different strategies and aims at different objectives. The introduction of the NIT in the fields of learning and education has implications for all the factors and actors concerned. The specific areas where future efforts will be concentrated will be identified and selected according to criteria which will inevitably reflect the different interests and priorities at play. Some of the decision making could focus on pure research needs, others on more immediate pay offs for education, or on economic or market imperatives. Yet other criteria would be based on chronological considerations, on how to achieve visible progress in the short possible time, while reserving a medium

or long-term perspective to commitments and investment that are not economically or politically justifiable in the short run.

169. The task of establishing and selecting among criteria would already be arduous in other circumstances. At present, it is made even more complex by reasons that are specific to the problems at stake. The crux of the matter is, once again, time. On one hand, there is an obvious and urgent need to invest in the area of learning and the NIT. The new information technologies, essentially micro-computers and particularly the least powerful among them, are entering the educational system in ever increasing numbers, and they are entering homes in numbers even larger. In the absence of action to the contrary, it is likely that bad habits will develop and consolidate in the school population, that the NIT will generate new forms of social discrimination that will reinforce the old ones, that expenditures in education or training would remain at unaffordable levels for the general economy. The situation clearly suggests urgency, but it also suggests caution.

170. In the historical development of the new information technologies, we are passing through that especially privileged early phase when most of the ground for future developments is laid down, often irreversibly. It is extremely important that now, rather than later, we establish as clear as possible a diagnosis of needs, problems and possibilities, and act accordingly. What we do at this stage will not be easily changed in the future. When considering the introduction of the new technologies in the formal educational system, and when considering research and development investments on learning, it is clear that in the implementation of the decisions taken there will be little space for "trail and error" strategies.

171. To have noticeable effects, the investments in resources, at all levels, are bound to be large. Past history teaches us that when large sums of resources are involved in setting up a new system, subsequent corrections are almost impossible to introduce. Large investments produce visible effects, but they also produce rigidity in the system and inertia towards modifications. The larger the financial investments in a system, the more costly the eventual adaptation to changes. The larger the number of people involved in the production process, the larger the production but also the more difficult the eventual modification of the production itself, should the need arise. Given the degree of ignorance we still have as to the likely deep effects of the new technologies on learning, and as long as this ignorance remains the only guide to important policy and research decisions, it is certainly hazardous, and rather risky to invest massively at the beginning, on the basis of choices and priorities that could well turn out to be premature.

172. The working agendas drawn in this section are only indicative. They are also exceedingly biased by the kind of hardware used in the research and experimentation and the basis of the data analysed. Computer technology evolves fast. Other information technologies might become available on a large scale. Different technologies, currently only marginal to education, or even new technologies could enter the schools of the future. With the evolution of the hardware configurations available, their impact on learning processes could also undergo significant changes, with them the longevity of the problems and issues considered in this report could also change, and the working agendas altered accordingly.

173. Yet, if we do not invest on a large scale in the present, we will not

have the body of information we need to take further decisions, we will not know how to best insure equality of opportunities, how to modify curricula for different ages of the school population or different courses of studies. The dilemma of initiating actions that are bound to generate gains and losses simultaneously is a very familiar one to policy makers. No doubt, the same care will have to be used in the field of "NIT, learning and education" as has been the case for other educational transformations. In this respect, at least, the new information technologies have nothing new to propose.

BIBLIOGRAPHY

Anderson, Richard C. (1983), "Reading Research and Reading Practice", Computers in Education, (Office of the Assistant Secretary for Educational Research and Improvement, Washington).

Becker, Henry J. (1982), Microcomputers in the classroom: dreams and realities, (Centre for Social Organization of Schools, The John Hopkins University, Report no. 319).

Bracey, G.W. (1982), "Computers in Education: What the Research Shows", Electronic Learning, November/December 1982.

Burnett et al. (1983), A multisite Evaluation of the Creative Use of Microcomputers by Elementary School Children, Interim Report No. 1, (Faculty of Education, Queen's University, Kingston, Canada).

Carroll, L. (1972), Alice's Adventures in Wonderland, (Dover Publications Inc., New York).

CLEA (1983), Computer Aids in Education: Presenting the Princess Project, (Computer-based Learning Environments, Stockholm).

Collins, Allan (1982), Teaching Reading and Writing with Personal Computers, (Bolt, Beranek and Newman Inc., Cambridge, Massachussetts).

Crossley, J.K. (1983), The Impact of the New Information Technologies on Learning Processes within formal education in Canada, Report to OECD/CERI.

CSOS (Center for Social Organisation of Schools) (1983 and 1984), School Uses of Microcomputers The Johns Hopkins University, Baltimore MD, Issue No. 1 April 1983, Issue No. 2 June 1983, Issue No. 3 October 1983, Issue No.4 February 1984.

Davis, Robert B. (1983), "The Acquisition of Mathematical Knowledge", Computers in Education, (Office of the Assistant Secretary for Educational Research and Improvement, Washington).

Doise, Willem and Mugny, Gabriel (1981), Le développement social de l'intelligence, (Interéditions).

FBCS (Federation of Behavioural, Psychological and Cognitive Sciences) (1983), Research on Cognition and Behaviour Relevant to Education in Mathematics, Science and Technology. Submitted to the National Science Commission on Precollege Education in Mathematics, Science and Technology, USA.

Feurzeig, W., Horwitz, P. and Nickerson, R.S. (1981), Microcomputers in education, (Bolt, Beranek and Newman Inc., Report no. 4798).

G.I.D.E.S. (Groupe Informatique de l'enseignement secondaire), (Informatique/Information, Genève), Dec 1983, No. 8

Godfrey and Sterling (1982), The Elements of CAL, (Press Porcépic, Victoria, Canada).

Goodlad, John I. (1983), A study of Schooling: some Implications for School Improvement, Phi Delta Kappan, April 1983

Gundlach, Robert A. (1983), "The Place of Computers in the Teaching of Writing", Computers in Education, (Office of the Assistant Secretary for Educational Research and Improvement, Washington).

Hirsch, E.D. (1983), "Cultural Literacy", Computers in Education, (Office of the Assistant Secretary for Educational Research and Improvement, Washington).

INRP (Institut National de Recherche Pédagogique) (1981), "Dix ans d'informatique dans l'enseignement secondaire: 1970-1980", Recherches pédagogiques, No. 113, 1981

Kane, J.H. (1983), Computer for Composing, paper presented at the annual conference of the AERA, Montreal, April 1983. As mentioned in Logan 1983.

Kundera, M. (1984), L'insoutenable légèreté de l'être, (Gallimard, Paris).

Kulik, J.A., Kulik, C.C. and Cohen, P.A. (1980), "Effectiveness of Computer-based College Teaching: A Meta-analysis of Findings", Review of Educational Research, No. 50.

Logan, Robert et al., (1983), Research Questions on the Impact of Computers in the Classroom, The Ontario Institute for Studies in Education, University of Toronto.

Miller, J.P. (1982), Teachers in Transition: Study of an aging Teaching force (OISE Press, Toronto). As mentioned in Logan, 1983.

MTS (Manitoba Teachers' Society) (1983), Computers in Education: Report of the Task Force on Implications and Use of Computers in Education, (Winnipeg, May 1983). As mentioned in Logan 1983.

Naymark, Jacques (1983), Impact sur les processus d'apprentissage en milieu scolaire formel en France, Report to OECD/CERI.

Nickerson, Raymond S. (1982), Understanding understanding, (Bolt, Beranek and Newman Inc.), Report No. 5087.

Papert, S. (1980), Mindstorms: Children, Computers and Powerful Ideas, (Basic Books).

Pea, Roy D. and Kurland, D. Midian (1984), "On the Cognitive Effects of Learning Computer Programming", New Ideas in Psychology, Vol.2, (a Pergamon Press Journal)

Reeves, H. (1981), Patience dans l'azur : l'évolution cosmique, (Seuil, Paris).

Robert, F. (1982), Communication au "Premier Colloque LOGO", Clermont Ferrand, December 1982.

Ruoppila, Isto (1983), The Impact of the New Information Technologies on Learning Processes within Formal Education: A clarifying Report based on Scandinavian Experiences and Research Data. Report to OECD/CERI.

Toepfer, Conrad F, Jnr. (1982), Brain Growth Periodization Research: Curricular Implication for Nursery through Grade 12 Learning, (Department of Learning and Instruction, State University of New York at Buffalo), ERIC Document No. ED 204 835

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International Conference on
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Château de la Muette
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EDUCATION AND NEW INFORMATION TECHNOLOGIES:

OVERALL TRENDS AND ISSUES

(Note by the Secretariat)

1. The attached, prepared by the Secretariat, presents a synthesis of the main trends and issues as they emerge from the background reports to the Conference. It will serve as an overall reference document to the discussions in both the Plenary Sessions and the Working Groups.

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I. CONTEXT

The Challenge of the New Information Technologies

1. In their hundred years of life, public systems of education have never ceased to undergo important developments. Their size, coverage and internal structure have changed. They have multiplied their objectives and the target groups have expanded and diversified. Yet very few of these changes have challenged the original principles of the organisation of education. Since the beginning, education has remained a labour intensive sector, employing almost exclusively specialised manpower on not so diversified tasks, with remarkably constant production methodologies and delivery systems. The current technological revolution (computer-based interactive devices, telecomunications) is pressing education towards yet further change. Once again the question is raised of how education can or indeed should respond and at what costs for its own functions and organisation. Obviously, the situation is not new to education nor does it necessarily constitute a problem for it. Theoretically, the system could respond to the pressure as in the past, by resisting it or by changing yet again what has been modified before, while leaving its basic organisational principles unaltered. Or else, it can engage in profound reshaping and remodelling, especially if the former types of response prove to be not entirely applicable in the present circumstances.

2. The analysis carried out within the CERI project on Education and the New Information Technologies has attempted to clear the ground for such a debate. Its central hypothesis recognises the situation as essentially new to education in a number of important aspects. First, the educational potential of the new generation of information technologies is larger than had been anticipated a decade ago on the basis of the computer-based teaching/learning methodologies developed at the time. The developments analysed within the project show that they could be more than a support tool for the teacher or a new subject in the curriculum. The new information technologies have also the potential to change education radically in its very structure and organisation, in terms of manpower (numbers, competence profiles, task diversity, etc.) and of production and delivery mechanisms.

The Web of Influences

3. The response of education to such potential -- and this is the second hypotesis in the analysis -- will necessarily reflect the powerful influence of a number of factors external to education. It cannot but reflect the penetration of the technologies in all spheres of society, of the awe, fear and expectations that this entails at all levels of the population, of the new learning needs that emerge as a consequence, of the new and urgent demands from the economy, for specialised manpower as well as for a larger market for

the new electronic products. The social, cultural and economic demands posed by new technologies of information as well as the attitudes towards these technologies all impinge on education. They raise forces and pressures to monitor and to stir educational courses so that new educational objectives can be defined and achieved in agreement with, or in support of, other new objectives, of a social, economic and political nature.

4. Faced with a challenge to its own functions and organisation and the interference of other non-educational forces, education could very well be tempted to resist the demand for "technological" change. Yet -- and this is the third hypothesis in the analysis -- it is debatable whether this attitude can be allowed to prevail. Education can hardly ignore this pressure for change. As part of the service sector, education is invested with the same imperatives as the rest of the sector, and indeed of the economy as a whole, forced to change and adapt to the new technological world, in order to remain financially viable. Next to the economic argument, which a number of educators could reject on the legitimate grounds that the functions of education cannot and should not be evaluated exclusively in financial terms, is the reality that education cannot ignore any large scale social change, without running the risk of loosing legitimacy as an institution and credibility as a service.

The Timing of the Technological Challenge

5. The task before education is a formidable one, its difficulties being increased by the timing of the challenge before it. The challenge of the technologies comes at a time of crisis for most educational systems. Few of the countries are likely to be in a position to tackle the "technological" issues serenely for some time. Few of the decision-makers in education will be spared the temptation to consider the technologies in relation to the crisis, i.e. to consider only those aspects of them which could be useful to find solution to the crisis -- rather than in relation to education, i.e., to look upon the full potential of the technologies for organising a possibly different, and better, service.

II. ROLES AND RESPONSIBILITIES

The Emergence of National Policies

6. By mid 1984, all Member countries are to be actively engaged and to have made progress in introducing the new information technologies in education. They all have achievements to show, and doubts to share, with other countries. In a number of them, experience has accumulated since the beginning of the 70s, when the technologies (mainly computer technology, essentially main frame computers) were first used for educational applications. No clear-cut consensus emerged then on the educational advantages of using these instead of "softer" teacher-based methodologies. During the past few years, and essentially under the impact of the new generations of computers -- the mini and microcomputers -- the educational involvment in the area has taken a new momentum in all countries. The alleged reasons are the cost/performance ratios of the new hardware, more favourable

than in the past, its potential for flexible and interactive use, its size, small enough to fit ordinary educational settings. At present, in a large -- and increasing -- number of Member countries, the developments have become important enough to warrant viewing the introduction of information technology in education as an object of coordinated development programmes, nationwide, under the responsibility of the public authorities.

Parallel Developments

7. Next to these more recent formal involvments -- usually reflected in coherent and exhaustive formulations of educational policy -- and as a continuation of the earlier phases of development, virtually each country has its own examples to show of important ongoing contributions from a variety of other sources. Next to state or regional educational authorities, groups of teachers, clubs, parents' associations, teacher unions, the media, commercial producers, and sometimes other non-educational public authorities, are all playing some role and investing some resources in the development of different literacies, different ways of learning and of accessing information, different bodies of knowledge and skills to acquire. The combination of these formal and informal, coordinated and haphazard initiatives, all reflecting particular expertise, motivation and interests as well as different histories of past experiences, results in national situations that are very varied in their outlook, in terms of content and scope, coordination, administration, juridical status, allocation of roles and responsibilities, and, finally, educational products made available to the clients: the pupils, the students and the public at large. Although their relative weight is difficult to assess with any degree of precision, a number of these "independent" developments seem to be comparable in their objectives, investments and results to the efforts deployed on a more formal basis. The link between what is done in and for the formal educational sector and what is developing elsewhere, and the impact of one kind of development on the other, are important issues to consider for education as they remain, for the time being, rather obscure.

Objectives and Priorities for Policy

8. The objectives at the basis of formal policy formulations are similar across countries in that they recognise the NIT as holding a great potential for education. But they do not necessarily take the same stance as to the specific contribution the technologies might make, as to whether technologies are to be included in the body of knowledge all citizens should have in order to function in society, whether the NIT are a matter to consider solely in terms of vocational education, whether the NIT hold a beneficial potential to the institution of education more than, or as well as, to the learner. The diversity of the objectives is reflected partly in the different approaches of the policies therein. If virtually all policies establish priorities, in the short if not in the medium term, they sometimes differ as to the definition of the entry point into the system. Two broad classifications of policy approaches can be developed in this respect. The first, defined in terms of the educational lines affected, covers two main groups of policies. The "vocational" group, most common in Member countries where the vocational education tradition is very strong, aims at introducing the NIT in vocational (commercial and technical) education to the exclusion of the general

educational sectors, sometimes earmarked for later investments. The "comprehensive" group of policies, on the contrary, does not privilege one sector over the other. Policies of this kind are more common in countries where the vocational and general educational sectors are formally merged within postcompulsory provisions or where the vocational tradition is not particulary strong within formal education.

9. A second broad classification of policies can be defined in terms of the priorities established for public investments and responsibilities by "front". Whatever the educational line adressed, the introduction of the NIT in education involves developments at different levels, such as equipment, curriculum and software and teacher training. Only a few of the national policies developed so far cover the totality of these critical fronts. Most of them establish public responsibilities within an explicit or implicit priority list, by front. Some of the policies consider that governments have a main responsibility in the equipping of educational establishments (either directly, by providing the hardware, or indirectly, through mechanisms of financial support targetted at purchase), or in providing financial and logistic support for curriculum development. Fewer policies target governamental involvment to the production and/or diffusion of software or at least to the coordination of its production/diffusion on a national basis. Yet fewer policies, although recognising it as an important issue, have devoted the bulk of the public resources available to the development of teacher training provisions. Each one of the above differences can be expected to have consequences on the education provided as well as on the evolution of the institution itself, at least in the short and medium range.

The Link with Industrial Development

10. Besides these differences, two broad similarities can be recognised across policies. One is the strong link of educational policies to national policies of industrial development: the equipment for which governments take financial or administrative responsibility is usually produced nationally. Countries where technologies other than microcomputer technology (usually telecommunication technologies) are the object of public investments in education are those where these other technological sectors have been given high national priority in industrial development. To the extent that the latter usually lean on weak pedagogical grounds, these links raise important issues for the possible impact of the technologies thus selected on the former.

Flexibility and Uncertainty

11. The other similarity concerns the life-time of policies. Usually, national policies have been formulated as short term, with a maximum time perspective of five years. At times this corresponds to explicit policy strategies. In some countries, central authorities act as supporters and initiators with a view to handing over to local authorities their commitments and responsibilities after an initial launching period. In other countries, the short-term policy formulations correspond to a two-phase policy design: a first period of controlled experimentation followed by a longer phase of large scale diffusion into main stream education, which might or might not involve a shift of roles and responsibilities between central and peripheral authorities. Yet in other countries, the short-term perspectives of the

policy are the ones usually adopted in similar cases, given the uncertainty, the risks and the difficulties of the task at hand. In these instances, the policies are explicitly marked as "first instalments", with an explicit committment by the educational authorities to review the situation at the end of the period although with no indications as to the life-time expected for the more "mature" policy decisions. Obviously, these different approaches to time differentiate policies in their degree of rigidity and flexibility as generators of answers to the questions, continuously changing and multiplying, raised for education by the impact of the NIT on all sectors of society. Such emphasis on uncertainty -- of objectives as well as of practice -- as a basis for policy is a major issue to consider in this field.

The Cost/Benefit Argument

12. As policy objectives are identified and resources allocated to implementing them, the economic concerns grow stronger. How much will it all cost? For what benefits? Who will pay? For how long? The introduction of the new information technologies in education is already showing the (important) breadth and depth of the processes involved, their (long) time span, and the amount of resources likely to be needed on the way -- much larger than the initial investments by governments. Yet, despite the clarity of such emerging trends, the task of assessing costs and benefits remains difficult to the economist. Most of the available data are on expenditure rather than costs. In particular, virtually no information exists on opportunity costs. Little is known on the amount of resources invested by non-public, non-formal bodies in this area. The balance between public and private expenditure is therefore obscure as is its possible evolution. Furthermore, the much voiced argument of the irresistible decline of hardware prices -- a weighty item in the expenditure bill -- is losing ground as the new production seems to obey a different evolution of the market, with the price-to-power ratios decreasing more often than the prices.

13. To complicate matters, the "benefit" side of the equation is proving to be as elusive as the "cost" one. Some of the reasons are familiar. They are raised by those who see the functions of education in larger terms than just teaching and learning, thus making eventual "technological" benefits hard to assess. Other reasons are novel as they relate to some of the specific approaches taken by policy. A case in point in the current emphasis of investments in the education of specialised manpower. The trend, already strong in schools, is dominant in higher education. Given the current uncertainties in medium and long-term forecasts for specialised manpower -- for technicians and, especially, for professionals -- the "benefits" attached to current priorities in investments would tend to look even more uncertain.

III. OUTCOMES AND PRODUCTS

14. As an outcome of both policy and grassroot developments, a number of changes have occurred in are taking place in educational provisions concerning the NIT available in and out of schools, to the young as well as to the less young. The result is, for the time being, an array of provisions marked by a

high degree of variability at a number of levels: by countries, districts and schools, by curriculum, educational objectives and target groups. The variations observed correlate only modestly with the pre-existing differentiations of educational provisions and outcomes. In other words, the first generation of such "new", NIT related, educational provisions seems to have increased the degree of differentiation within the system, rather than the opposite. While this is not necessarily an issue in itself -- it might be a temporary condition or even correspond to a welcome evolution -- it is important to identify the various factors contributing to it with a view to understanding the possible implications for the future of education and the place of information technology within it.

Hardware and Software

15. On the equipment front, the current flow of hardware into the schools tends to be characterised by a narrow selection in terms of technology and a large one in terms of corresponding hardware. The material purchased in the larger numbers belongs to the family of computers. Other information technologies, such as telecommunications or optic fibres and cable technology are much less represented in both schools and universities, although the trend is stronger in the former than in the latter. The work stations usually found in educational establishments include micro or minicomputers, display screens, disk drivers, and printers. At times the configuration is linked to data bank networks, link-ups with video components such as videodiscs being rarer. Hardware configurations for distance education -- satellite, cable telecommunication -- are being introduced in some Member countries. In the majority of them, however, such equipment remains marginal to current policies and investments in education.

16. The hardware entering education in less formal ways tends to reflect a similar trend. Public and "grassroot" developments thus combine to enhance the same technological bias in education. To the extent that "computer power" sets boundaries to what can be achieved in terms of pedagogy, the selection of this particular type of technology introduces an important bias in the possible array of large-scale utilisations of the NIT in education. The type of computers found most often in schools are among the least powerful of the family that allows the more sophisticated pedogogical approaches. Their pedagogical applications are therefore also limited. The latest generations of micro and minicomputers, offering more "computer power" for the same price, can eventually offset the drawback in hardware. It remains to be seen if, when and how education can develop equipment policies and practices resourceful enough and flexible enough to increase its own "pedagogical power" accordingly.

17. The fact that they are of the same breed, does not necessarily make school computers uniform. In the absence of agreements and regulations on standards or standardisations, these computers tend to come in a number of models, each providing different performances, thus different advantages and drawbacks in their educational applications. Despite the (sometimes) unifying impact of official policies on equipment, the variety of the electronic market tends to be reproduced in educational establishments. This may possibly facilitate the tuning of the hardware to the specific needs of individual schools. Undoubtedly, it also creates important obstacles to the optimal utilisation of the capital of software produced in each country by aggravating problems of transportability across hardware.

Information Technologies in Education

18. The lack of transportability across hardware is only one of the several factors beleaguering the introduction of the NIT in education. More importantly, little consensus has emerged as yet as to the future role of the information technologies in education. Some educators and some schools view the computer as just another learning tool, one that will be important for instruction insofar as it facilitates teaching and learning, without necessarily taking any prominent place in the classroom. Others believe that the computer can make the dream of modern pedagogy come true: an individualised instruction and tutoring for all pupils and all students, at no extra cost for education. Yet others claim that the largest impact of the NIT will be on teachers, on their role and functions, on their numbers. Others still look wearily upon the computer as a gateway through which a new form of culture might come into the schools, a body of knowledge and skills defined -- perhaps -- in less than "human" terms.

19. Little of what is concretely happening in education provides enough information to tilt the debate in any one direction. For one, the information is in itself scarce. Not enough schools are sufficiently equipped to provide substantial grounds for experimentation. A common feature found in Member countries is of an average of a few micro or minicomputers per secondary school, with an average access time to students of less than half an hour per week. Usually primary schools are even less well equipped and vocational ones much better, especially in some sectors. In the latter, a number of countries are achieving an equipment target of a workstation for each ten, or fewer, students. In most schools, the few computers available are used essentially for drill-and-practice or remedial education, rather than as an aid to teaching, although examples of the latter are on the increase.

Computer Science in the Curriculum

20. In addition to being used as a tool for teaching and learning within established disciplines, computers are also being used as a teaching subject in its own right. This educational objective, common to most of the schools equipped with computers and to some of the others too, has translated, again, in a variety of educational provisions, which, especially in general educational lines, are difficult to accommodate within a single taxonomy. At times, teaching about computers is taken to mean the introduction of elements of computer science in established disciplines, at times the same subject matter is organised as a separate piece of the curriculum. At times it is the object of final examinations, at times it is not. At times it is enlarged to include considerations of the societal implications of the NIT, at times it is limited to computer programming, often to only one programming language. These variations co-exist in some countries, sometimes in the same educational line, and usually irrespective of the level of schooling considered. The only pattern showing some degree of consistency is the heavy bias of computer-related educational provisions in favour of the secondary as opposed to the primary educational level. This bias in curriculum is obviously reinforced by the equivalent imbalance in equipment.

The "Remote Control" on Education

21. One way to look at the present situation is to see education as engaged in a vast exercise of trial and error. To the extent that the ultimate objectives are reasonably clear and the processes under control, we might be witnessing a first exploratory phase of development, marked by a healthy degree of uncertainty, progressing towards a clear future. In this case, the work agenda of all those concerned would not differ much from that of other times on other changes. It would then be reasonable to expect that the issues be defined within education and the problems solved by members of the educational community. The reading could however be different. The variations and uncertainties observed in the response of education to the information technologies could stem from elsewhere, from sectors of development obviously related to education but eluding its authority.

22. The existence of such "remote control" on educational developments is an important issue to debate. Next to the influence of technological and industrial developments, other obvious candidates could easily be found in the sectors of software development and research on learning processes and applications of artificial intelligence. On the software front, most of the software used in education is that which has been produced within the system, by schools or by bodies especially created within educational authorities, with teachers as the main authors. With very few exceptions, commercial producers and research bodies specialised in computer sciences, whether or not linked to higher education institutions, have not taken a prominent role in the educational market. The quality of the results is recognised to be, at best, varied. The best type of educational software, the more sophisticated and sound pedagogically, tends to be the more costly to produce, drawing on the combined expertise of computer specialists, educators, cognitive psychologists, and software designers. This type tends also to be scarcer on the market compared with the more common kind built on rather unsophisticated programming and directed at lower level cognitive skills, such as drill and practice, enrichment and remediation. Issues of expertise, of costs and financing, of quality control, of copyright and of transportability are at the centre of current developments in the software area. They point to factors of variation within the market, which cannot but be reflected in education.

Impact on Learning

23. In addition to such technical issues, another major source of uncertainty in the introduction of the NIT in education lies undoubtedly within the area of research, marked by the lack of adequate information and understanding on what learning entails in terms of skills and processes as well as on the possible role of the technologies therein. The introduction of the NIT in the learning environment has been observed to lead -- although not systematically and according to modalities still uncharted -- to changed learner performances. The observed changes suggest some modification of the learning processes and of their cognitive and motivational determinants. In particular, the observed results throw doubts on some of the assumptions at the basis of current curriculum organisation, i.e. at what age one can expect formal reasoning abilities to develop, at what speed certain notions and skills can be learned. It is also observed that, similarly to what has been observed with other learning methodologies, the benefits of learning via the NIT are not equally distributed across the population. Such seemingly

unsurprising results become intriguing when noting that the profile (cognitve and motivational make-up) of the better performers does not necessarily reproduce the familiar profile of the "good achievers". For instance, good performance with the NIT has not been found to correlate to any conspicuous degree with "classic" indicators such as socio-economic background, sex, or mathematic abilities.

24. The implications of these findings might be far reaching for education, for its content as well as its organisation. If the NIT were spread evenly across the school population, the issue could then be raised of how the "profile" of the "new" achievers compares with their former profiles and of what the implications are in social and political terms, of how the curriculum should be re-organised across levels of schooling, across pupils' ages, across disciplines. Yet, without adequate information from research, these questions will remain unanswered, the implications for education uncertain, the degree of variation across educational provisions undiminished.

25. As long as a "critical mass" in production and understanding is not reached in the areas of software development and cognitive sciences, it could be argued that the introduction of the NIT in education is bound to remain limited to a level which is perhaps unjustifiable an a cost/efficiency basis. In particular, there will be no easy way to address the basic issue of what can and what cannot be achieved in education by way of the new information technologies. Yet, the list of possible benefits to draw from the information technologies -- from gains in learning and in access to learning facilities to the expansion of alternative ways of learning, such as distance education or through self-learning opportunities -- is appealing enough to warrant the effort of finding out. Waiting for a large enough body of information to accumulate, what remains to be discussed still is the role education could or would be prepared to play in this process.

Teacher Roles and Teacher Training

26. Besides the possible decisions taken by the educational authorities at the highest levels on the matter, the role that teachers are willing to play and the contributions they might be able to make remain central to this context. Yet compared with developments in equipment, software and research, the issue of teachers qualifies so far as having received much more of the attention than of the resources. The debate on the roles and functions of the teachers has taken momentum in a number of countries, yet only in very few of them teacher training provisions, to mention but a component of the problem, have been developped that meet the challenge. In these countries the target is set to cover, over only a few years, the totality of the teaching force or of at least some sectors in it, usually those in vocational education. Most of the other countries have either no formal provisions to report or only modest ones to show, aimed at yearly targets of no more than a few percentages of the teaching force. The more recent production of multimedia programmes for self-training, which can be run on the hardware commonly available in the school, could perhaps help solve this problem of numbers.

27. In the debate on teacher training, the issue of quantity is paralleled by that of quality. When they exist at all, teacher training provisions tend to be undifferentiated by level of education or by discipline. Furthermore, they do not distinguish among possible roles or functions with respect to the

use of the NIT in education. Finally, the large variety in the length and content of the existing courses indicates that the consensus, if not the understanding, is far from being reached across countries on what teachers are supposed to know, or able to assimilate, on the NIT. The uncertainty of the trend might however dissipate in not so distant a future. Both the grassroot and the more advanced formal developments in this area identify some new roles possibly emerging for the teacher. Roughly put, the trend points to the development of a "coordinator", a teacher having undegone, formally or informally, a training "heavy" enough to make him/her able to take the lead in schools. This teacher is the one observed to launch and maintain activities related to the NIT as a trainer of colleagues, as a producer of software, as organiser of extra-curricular activities for teachers, youngsters and the community at large. Interestingly enough, the "coordinator" seems to emerge irrespective of the existence of a formal level of employment corresponding to this new profile of competences and responsibilities, located somewhere between the ordinary teacher and the school head.

Computers and Social Control

28. While education is engaged in defining and (possibly) solving its own internal problems of curriculum and staff development, instruction in and by the NIT is also growing in the outside market. Additionally to the ad hoc training provisions developing in the economy, in both the service and the production sectors, the general trend is for a proliferation of provisions and opportunities made available to the general public by a variety of sources -- government, media, private sector, associations networks, social and cultural agencies -- these different bodies coming together occasionally for specific ventures. Like that in education, this production is also marked by a high degree of internal variation. At best, it provides a real, at times even a better, alternative to instruction within formal education. At worse, it offers informal and disorderly opportunities aimed at "overtaking" its target learners, to create in them artificial needs and to encourage them to consume products, the quality of which remains to be evaluated.

29. The existence of such "parallel" arrays of provisions is undoubtedly an element to consider when planning and implementing educational developments in the area of the information technologies. Its consequences for the role and responsibilities proper to education are questions open for discussion. The so called "computer literacy" is a most obvious first item on the list. Taken in its narrower definition of basic learning about the computer, it is perhaps debatable whether education should necessarily take the lead on more informal or private initiatives. But, to the extent that "computer literacy" might mean the acquisition of the ability to take advantage of the new information facilities without succumbing to their control -- a concern expressed by many -- the debate on the role and responsibility of education takes a more dramatic connotation. In this context the issues of public versus private and formal versus informal might mean to the learner the difference between using and being used.

IV. FUTURE WORK AGENDA

30. Given the general trend in the diffusion of the new information technologies in society, it is difficult to imagine that education could either remain marginal to the general climate of change, or survive unchanged in its structure, organisation and functions. Put differently, it is hard to believe that the forces behind the impact of the NIT on economic, social and cultural life could suddenly deflate at the doorsteps of our schools and universities. Indeed the signs indicate that the "technological revolution" has already made an inroad in education which might well be irreversible . The evidence also suggest that the process thus started, if sustained to its full institutional implications, is likely to be long, costly, complex and far reaching. In other words, the central issue to discuss is more likely to be one of "when" and "how" rather than "if" education will face the challenge.

The Achievement of "Critical Mass"

31. The issue of "critical mass" has come forcefully to the fore of the analysis as a first general and urgent objective to achieve. More equipment is needed in educational establishements, more research is needed on the impact of the NIT on learning and on the organisation of education. More trained teachers are needed, more pedagogical experimentation in the classrooms is necessary. More software of a higher quality for education needs to be developed. The level and quality of resources and expertise needed to achieve the objective surpass what can be found within any single educational system, or single regional authorities. It is even debatable whether they can be found solely within the public sector, in each country. Specific efforts of coordination and cooperation at national and international levels as well as across agencies and professional sectors seem to be urgent and necessary to achieve progress in education.

The Development of Evaluation

32. The need to accumulate experience and information is paralleled by the need to evaluate them. The technologies risk to introduce a bias of their own in teaching as well as in learning. They might privilege the development of those teaching methodologies and learning skills to which they apply. They might act as a distorting filter on the body of knowledge made available through them to pupils, students and the general public. The evaluation data produced so far has tended to be scarce and biased. We are informed about positive results much more often than about the others. We know little of the "technological" conditions that make no difference, and even less of what could be detrimental to learning or education.

The Prevention of Inequalities

33. Few of the OECD Member countries have enough resources to be able to solve all the problems rapidly or simultaneously. The trend in future developments is more likely to be one of establishing priorities. Depending on the ranking order adopted in each country, the issue that risks becoming central to policy and political considerations might well be that of access.

The response of education to the technologies is already showing patterns of differential access across recipients. The dividing lines are often familiar: rich vs poor schools, urban vs rural establishments, vocational vs general, secondary vs primary education, science vs humanities, boys vs. girls. The boundaries do not seem to be conspicuously different in higher education. The danger is already visible that efficiency could be achieved at the price of equity and equality.

The Need for Careful and Coordinated Policy Planning

34. The role of government will remain crucial in the near future to decide on courses of action, by defining objectives for policies and allocating responsibilities and resources for their implementation. In particular, it will remain as its responsibility to see that the interplay between the various agencies, public and private, formal and informal, develops constructively, and that the new objectives possibly established for education continue to reflect the mandate towards its customers. The new information technologies are the gateway to the society of the future, just as the industrial revolution was to the present one. That transition has improved people's life in many important respects, but this progress has not been free of costs. There are no reasons to expect that the "technological revolution" will give or take any less. A central question, therefore, is to what extent governments are prepared to use the authority and coverage that they have since gained over economic, social and educational matters to ensure appropriate control over the new developments so that the ultimate balance be a fair one.